

## U.S. DEPARTMENT OF COMMERCE PATENT &amp; TRADEMARK OFFICE

|   |   |  |   |
|---|---|--|---|
| B/O Form PTO-1390   |   | <b>Transmittal Letter to the United States<br/>Designated/Elected Office (DO/EO/US)<br/>Concerning a Filing Under 35 USC 371</b> | Attorney's Docket Number<br>KIMJ3008/REF/7077 |
|   |   |  | U.S. Application Number 097890249             |
| International Application Number<br>PCT/KR00/01385  | International Filing Date<br>30 November 2000 | Priority Date Claimed -<br>4 December 1999   |   |
| Title of Invention<br>TRANSMISSION AND RECEIVING USING SPREADING MODULATION FOR SPREAD SPECTRUM COMMUNICATIONS AND THEREOF<br>APPARATUS |   |  |   |
| Applicant(s) for DO/EO/US<br>KIM et al.   |   |  |   |

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items under 35 USC 371:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 USC 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 USC 371.
3. ☒ This express request to begin national examination procedures (35 USC 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 USC 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed 35 USC 371(c)(2).
  - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ has been transmitted by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 USC 371(c)(2)).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 USC 371(c)(3))
  - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ have been transmitted by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☐ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 USC 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 USC 371(c)(4)). ( ☒ Executed ☐ Unexecuted )
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 USC 371(c)(5)).

Items 11 to 16 below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.  
☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information: Applicants assert entitlement to small entity status.

|  |                     |   |             |  |              |
|--|---------------------|---|-------------|--|--------------|
| Application Number (if known)<br><b>09/890249</b>  |                     | International Application Number<br><b>PCT/KR00/01385</b> |             | Attorney's Docket Number<br><b>KIMJ3008/REF/7077</b> |              |
|  |                     |   |             | Calculations   | PTO USE ONLY |
| 17. The following fees are submitted:<br><b>Basic National Fee (37 CFR 1.492(a)(1)-(5)):</b><br><input type="checkbox"/> Search report has been prepared by the EPO or JPO ..... \$860.00<br><input type="checkbox"/> International Preliminary Examination Fee paid to USPTO (37 CFR 1.482) ..... \$690.00<br><input type="checkbox"/> No International Preliminary Examination Fee paid to USPTO (37 CFR 1.482)<br>but International Search Fee paid to USPTO (37 CFR 1.445(a)(2)) ..... \$710.00<br><input checked="" type="checkbox"/> Neither International Preliminary Examination Fee (37 CFR 1.482) nor<br>International Search Fee (37 CFR 1.445(a)(2)) paid to USPTO ..... \$1000.00<br><input type="checkbox"/> International Preliminary Examination Fee paid to USPTO (37 CFR 1.482)<br>and all claims satisfied provisions of PCT Article 33(1)-(4) ..... \$100.00 |                     |   |             | \$1,000.00   |              |
| <b>ENTER APPROPRIATE BASIC FEE AMOUNT</b>  |                     |   |             | <b>\$ 1,000.00</b>                                   |              |
| Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).  |                     |   |             |  |              |
| <b>CLAIMS</b>  | <b>NUMBER FILED</b> | <b>NUMBER EXTRA</b>                                       | <b>RATE</b> |  |              |
| Total Claims   | 13 -20 =            | 0   | × \$18.00   | \$ 0.00  |              |
| Independent Claims   | 4 -3 =              | 1   | × \$80.00   | \$ 80.00   |              |
| Multiple Dependent Claims (if applicable)  |                     |   | + \$270.00  |  |              |
| <b>TOTAL OF ABOVE CALCULATIONS</b>   |                     |   |             | <b>\$ 1,080.00</b>                                   |              |
| Reduction by 1/2 for filing by small entity, if applicable. Small Entity Status is asserted pursuant to 37 CFR 1.27 for this application.  |                     |   |             | \$ 540.00  |              |
| <b>SUBTOTAL</b>  |                     |   |             | <b>\$ 540.00</b>                                     |              |
| Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).   |                     |   |             |  |              |
| <b>TOTAL NATIONAL FEE</b>  |                     |   |             |  |              |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property.  |                     |   |             | \$ 40.00   |              |
| <b>TOTAL FEES ENCLOSED</b>   |                     |   |             | <b>\$ 580.00</b>                                     |              |
|  |                     |   |             | Refunded:  |              |
|  |                     |   |             | Charged:   |              |

- a. ☒ A check in the amount of \$580.00 to cover the fees is enclosed.
- b. ☐ Please charge my **Deposit Account Number 02-0200** in the amount of \$\_\_\_\_\_ to cover the above fees.  
A duplicate copy of this sheet is enclosed.
- c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to **Deposit Account Number 02-0200**. A duplicate copy of this sheet is enclosed.

Note: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

**BACON & THOMAS, PLLC**  
 625 SLATERS LANE - FOURTH FLOOR  
 ALEXANDRIA, VIRGINIA 223124-1176  
 (703) 683-0500

DATE: August 2, 2001

Respectfully submitted,

*Richard E. Fichter*

Richard E. Fichter  
 Attorney for Applicant  
 Registration Number: 26,382

PATENT

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re application of:

KIM et al.

U.S. National Phase of PCT/KR00/01385

Entry papers filed herewith August 3, 2001

Attention: PCT OFFICE

For: TRANSMISSION AND RECEIVING USING SPREADING MODULATION FOR  
SPREAD SPECTRUM COMMUNICATIONS AND THEREOF APPARATUS

**PRELIMINARY AMENDMENT**

Assistant Commissioner for Patents  
Washington, D.C. 20231

Sir:

The present application is the U.S. national phase of international application  
number PCT/KR00/01385.

Please amend the above-identified application as follows:

**IN THE SPECIFICATION:**

Please add the attached ABSTRACT OF THE DISCLOSURE to the application.

**IN THE CLAIMS:**

Please replace claim 4 with the following amended claim 4.

4(Amended). A transmitting method as defined in claim 2, wherein the orthogonal  
complex-domain spreading is performed with orthogonal Hadamard codes and the  
scrambling codes for the complex-domain scrambling are produced using orthogonal  
Hadamard codes.

Please add the following new claim to the application.

13(New). A transmitting method as defined in claim 3, wherein the orthogonal complex-domain spreading is performed with orthogonal Hadamard codes and the scrambling codes for the complex-domain scrambling are produced using orthogonal Hadamard codes.

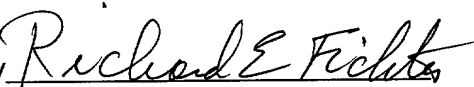
**REMARKS**

Applicants have amended the claims in order to reduce the initial filing fee by deleting the multiple dependent claims from the application. Applicants have reintroduced the subject matter canceled by the present Amendment by adding new claim 13 to the application.

Applicants understand that, under the procedures of the PCT, a copy of the priority document (KR 54963, filed December 4, 1999) will have been supplied to the U.S. Patent Office pursuant to Rule 17 of the PCT Regulations. It is therefore respectfully requested that the first Official Action in the present application contain an indication that the appropriate priority document is in the file of this application.

In view of the above amendments, an early action on the application is now in order and is most respectfully requested.

Respectfully submitted,  
BACON & THOMAS, PLLC

By   
RICHARD E. FICHTER  
Registration No. 26,382

625 Slaters Lane - 4th Floor  
Alexandria, Virginia 22314  
Phone: (703) 683-0500  
Facsimile: (703) 683-1080

REF:kdd  
PA01.wpd

DATE: August 2, 2001

**Marked-Up Version Showing Changes Made**

**IN THE CLAIMS:**

Please replace claim 4 with the following amended claim 4.

4(Amended). A transmitting method as defined in claim 2 [or 3], wherein the orthogonal complex-domain spreading is performed with orthogonal Hadamard codes and the scrambling codes for the complex-domain scrambling are produced using orthogonal Hadamard codes.

21/PTS

TRANSMISSION AND RECEIVING USING SPREADING  
MODULATION FOR SPREAD SPECTRUM COMMUNICATIONS AND  
THEREOF APPARATUS

5 TECHNICAL FIELD

10 This invention is concerned with spreading modulation methods for orthogonal multiple channel transmitters in CDMA (code division multiple access) communication systems. More particularly it is related to orthogonal complex-domain spreading modulation methods for CDMA communication systems when there are channels with statistically higher transmitting power.

15

BACKGROUND ART

20 In description of the prior art, the same reference number is used for a component having the same function as that of the present invention. FIG. 1 shows a schematic diagram for a conventional CDMA transmitter with orthogonal multiple channels. The

transmitter in FIG. 1 is based on the cdma2000 system, which is one of the candidates for IMT-2000 (International Mobile Telecommunications-2000) system as a third generation mobile communication systems. The transmitter has 5 orthogonal channels: A Pilot CHannel (PiCH) used for coherent demodulation; a Dedicated Control CHannel (DCCH) for transmitting control information; a Fundamental CHannel (FCH) for transmitting low speed data such as voice; and two Supplementary CHannels (SCH; SCH1, SCH2) for high-speed data services. Each channel passes through a channel encoder and/or an interleaver (not shown in FIG. 1) according to the required quality of the channel.

Each channel performs the signal conversion process by changing a binary data {0, 1} into {+1, -1}. Even though it is explained with the changed {+1, -1}, our method can be equally applied to the information represented by several bits, for example, {00, 01, 11, 10} is changed into {+3, +1, -1, -3}. The gain for each channel is controlled based on the required quality and transmitting data rate by using



the gain controllers  $G_P(110)$ ,  $G_D(112)$ ,  $G_{S2}(114)$ ,  $G_{S1}(116)$ , and  $G_F(118)$ . The gain for each channel is determined by a specific reference gain, and the amplifiers (170, 172) control the overall gain. For example, with  $G_P = 1$ , other gain  $G_D$ ,  $G_{S2}$ ,  $G_{S1}$ , or  $G_F$  can be controlled. Gain controlled signal for each channel is spread at the spreader (120, 122, 124, 126, 128) with orthogonal Hadamard code  $W_{PICH}[n]$ ,  $W_{DCCH}[n]$ ,  $W_{SCH2}[n]$ ,  $W_{SCH1}[n]$ , or  $W_{FCH}[n]$ , and is delivered to the adder (130, 132).

Hadamard matrix,  $H^{(p)}$ , comprising the orthogonal Hadamard codes has the following four properties:

(1) The orthogonality is guaranteed between the columns and the rows of an Hadamard matrix.

When

【EQUATION 1】

$$H^{(p)} = H_{p \times p} = \begin{bmatrix} h_{0,0} & h_{0,1} & \cdots & h_{0,p-1} \\ h_{1,0} & h_{1,1} & \cdots & h_{1,p-1} \\ \vdots & \vdots & \ddots & \vdots \\ h_{p-1,0} & h_{p-1,1} & \cdots & h_{p-1,p-1} \end{bmatrix} =$$



also an Hadamard matrix.

【EQUATION 3】

$$\begin{aligned}
 H_{mn \times mn} &= A_{m \times m} \otimes B_{n \times n} \\
 &= \begin{bmatrix} a_{0,0} & a_{0,1} & \cdots & a_{0,m-1} \\ a_{1,0} & a_{1,1} & \cdots & a_{1,m-1} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m-1,0} & a_{m-1,1} & \cdots & a_{m-1,m-1} \end{bmatrix} \otimes \begin{bmatrix} b_{0,0} & b_{0,1} & \cdots & b_{0,n-1} \\ b_{1,0} & b_{1,1} & \cdots & b_{1,n-1} \\ \vdots & \vdots & \ddots & \vdots \\ b_{n-1,0} & b_{n-1,1} & \cdots & b_{n-1,n-1} \end{bmatrix} \\
 &= \begin{bmatrix} b_{0,0}A & b_{0,1}A & \cdots & b_{0,n-1}A \\ b_{1,0}A & b_{1,1}A & \cdots & b_{1,n-1}A \\ \vdots & \vdots & \ddots & \vdots \\ b_{n-1,0}A & b_{n-1,1}A & \cdots & b_{n-1,n-1}A \end{bmatrix} = \begin{bmatrix} h_{0,0} & h_{0,1} & \cdots & h_{0,mn-1} \\ h_{1,0} & h_{1,1} & \cdots & h_{1,mn-1} \\ \vdots & \vdots & \ddots & \vdots \\ h_{mn-1,0} & h_{mn-1,1} & \cdots & h_{mn-1,mn-1} \end{bmatrix}
 \end{aligned}$$

The present invention describes CDMA systems using the column vectors or row vectors of a  $2^n \times 2^n$  Hadamard matrix  $H^{(2^n)}$  as orthogonal codes, where the  $2^n \times 2^n$  Hadamard matrix  $H^{(2^n)}$  is generated from a  $2 \times 2$  Hadamard matrix as shown in EQUATION 4 ( $n = 1, 2, 3, \dots, 8$ ). In particular, the set of the column vectors or the row vectors of the produced Hadamard matrix is  $2^n$  dimensional Walsh codes.

【EQUATION 4】

$$H^{(2)} = H_{2 \times 2} = \begin{bmatrix} +1 & +1 \\ +1 & -1 \end{bmatrix} = \begin{bmatrix} W_0^{(2)} \\ W_1^{(2)} \end{bmatrix}$$

$$H^{(4)} = H_{4 \times 4} = H_{2 \times 2} \otimes H_{2 \times 2} = \begin{bmatrix} +1 & +1 & +1 & +1 \\ +1 & -1 & +1 & -1 \\ +1 & +1 & -1 & -1 \\ +1 & -1 & -1 & +1 \end{bmatrix} = \begin{bmatrix} W_0^{(4)} \\ W_1^{(4)} \\ W_2^{(4)} \\ W_3^{(4)} \end{bmatrix}$$

$$H^{(8)} = H_{8 \times 8} = H_{2 \times 2} \otimes H_{4 \times 4} = \begin{bmatrix} +1 & +1 & +1 & +1 & +1 & +1 & +1 & +1 \\ +1 & -1 & +1 & -1 & +1 & -1 & +1 & -1 \\ +1 & +1 & -1 & -1 & +1 & +1 & -1 & -1 \\ +1 & -1 & -1 & +1 & +1 & -1 & -1 & +1 \\ +1 & +1 & +1 & +1 & -1 & -1 & -1 & -1 \\ +1 & -1 & +1 & -1 & -1 & +1 & -1 & +1 \\ +1 & +1 & -1 & -1 & -1 & -1 & +1 & +1 \\ +1 & -1 & -1 & +1 & -1 & +1 & +1 & -1 \end{bmatrix} = \begin{bmatrix} W_0^{(8)} \\ W_1^{(8)} \\ W_2^{(8)} \\ W_3^{(8)} \\ W_4^{(8)} \\ W_5^{(8)} \\ W_6^{(8)} \\ W_7^{(8)} \end{bmatrix}$$

The orthogonal Walsh codes of the above mentioned Hadamard matrix  $H^{(p)}$  have the following property ( $p = 2^n$ ).

【EQUATION 5】

$$\begin{aligned} W_i^{(p)} \odot W_j^{(p)} &\equiv (w_{i,0}^{(p)}, w_{i,1}^{(p)}, \dots, w_{i,p-1}^{(p)}) \odot (w_{j,0}^{(p)}, w_{j,1}^{(p)}, \dots, w_{j,p-1}^{(p)}) \\ &= (w_{i,0}^{(p)} w_{j,0}^{(p)}, w_{i,1}^{(p)} w_{j,1}^{(p)}, \dots, w_{i,p-1}^{(p)} w_{j,p-1}^{(p)}) \\ &= (w_{k,0}^{(p)}, w_{k,1}^{(p)}, \dots, w_{k,p-1}^{(p)}) \\ &= W_k^{(p)} \end{aligned}$$

Where  $\{i, j, k\} \subset \{0, 1, 2, \dots, 2^n - 1\}$ . If  $i, j, k$  are represented by binary numbers as in EQUATION 6,

【EQUATION 6】

$$i = (i_{n-1}, i_{n-2}, i_{n-3}, \dots, i_1, i_0)_2, \quad j = (j_{n-1}, j_{n-2}, j_{n-3}, \dots, j_1, j_0)_2,$$

$$k = (k_{n-1}, k_{n-2}, k_{n-3}, \dots, k_1, k_0)_2$$

the following relation holds among  $i, j, k$ :

## 【EQUATION 7】

$$(k_{n-1}, k_{n-2}, k_{n-3}, \dots, k_1, k_0)_2 = (i_{n-1} \oplus j_{n-1}, i_{n-2} \oplus j_{n-2}, i_{n-3} \oplus j_{n-3}, \dots, i_1 \oplus j_1, i_0 \oplus j_0)_2$$

Here  $\oplus$  represents the eXclusive OR (XOR) operator.

Therefore,  $W_i^{(p)}[n] = W_i^{(p)}[n] W_0^{(p)}[n]$  for  $i \in \{0, 1, 2, \dots, 2^n -$

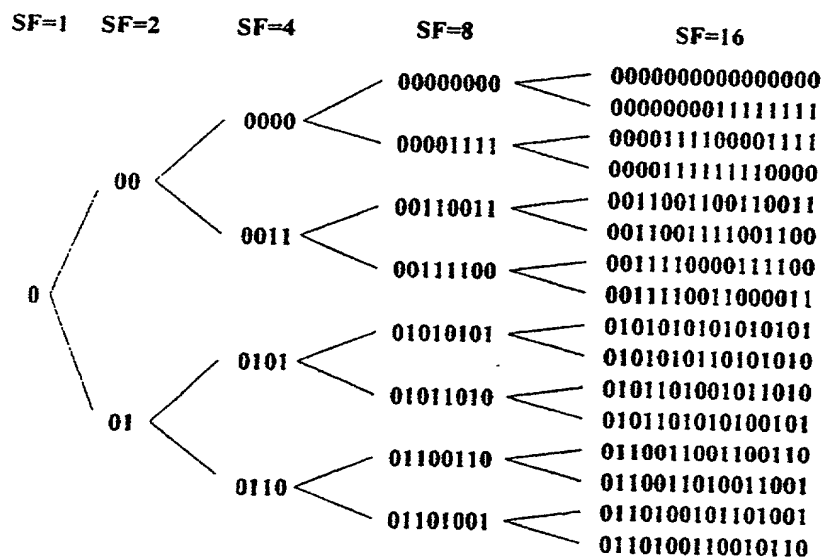
5  $1\}$ , and  $W_{2k+1}^{(p)}[n] = W_{2k}^{(p)}[n] W_1^{(p)}[n]$  for  $k \in \{0, 1, 2, \dots, 2^{n-1} -$   
1 $\}$ .

In order to distinguish the orthogonal multiple channels, the Hadamard matrix  $H^{(p)}$  is used, and the order of the Hadamard matrix  $H^{(p)}$ ,  $p (= 2^n)$  is the Spreading Factor (SF). In direct sequence spread spectrum communication systems, the spreading bandwidth is fixed, so the transmission chip rate is also fixed. When there are several channels having different data transmission rates with a fixed transmission chip rate, the tree-structured Orthogonal Variable Spreading Factor (OVSF) codes are used (as shown in EQUATION 8) in order to recover the desired channels at the receiving terminal using the orthogonal property of the channels.

The OVSF codes with conversion ("0"  $\leftrightarrow$  "+1" and

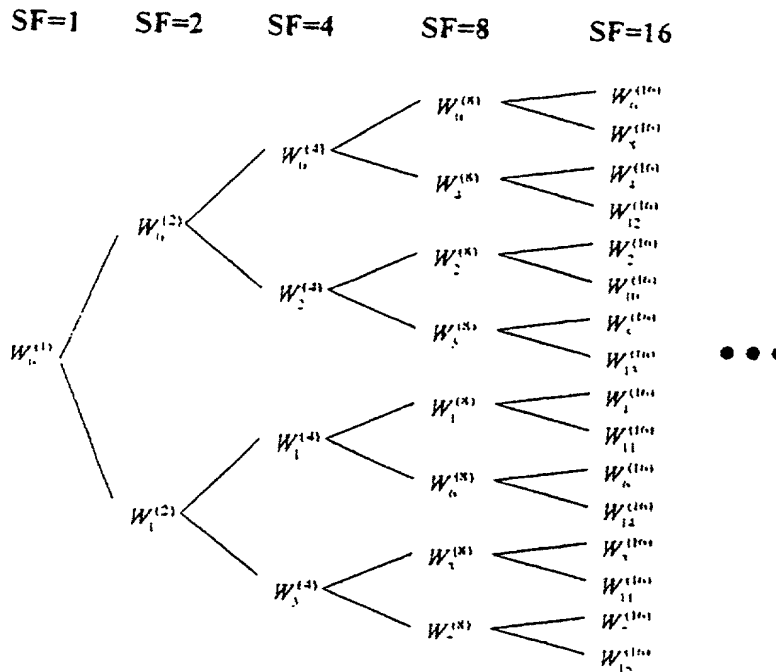
"1"  $\leftrightarrow$  "-1") and orthogonal Walsh functions are shown in EQUATION 8 and EQUATION 9, respectively. An allocation method of the tree-structured OVSF codes with the orthogonal property is shown in the following references: (1) F. Adachi, M. Sawahashi and K. Okawa, "Tree-structured generation of orthogonal spreading codes with different lengths for forward link of DS-CDMA mobile radio," Electronics Letters, Vol.33, Jan.1997, pp27-28. (2) US Patent # US5751761, "System and method for orthogonal spread spectrum sequence generation in variable data rate systems".

## 【EQUATION 8】



The above equation shows the OVSF codes.

【EQUATION 9】



The above equation shows the relation between the  
5 OVSF codes and orthogonal Walsh codes.

The outputs  $(x_T[n], y_T[n])$  of the adder (130,  
132) in FIG. 1 can be written as the following  
equations:

【EQUATION 10】

$$\begin{aligned}
 x_T[n] &= G_P W_{PiCH}[n] D_{PiCH} \left[ \left\lfloor \frac{n}{SF_{PiCH}} \right\rfloor \right] + G_D W_{DCCH}[n] D_{DCCH} \left[ \left\lfloor \frac{n}{SF_{DCCH}} \right\rfloor \right] \\
 &\quad + G_{S2} W_{SCH2}[n] D_{SCH2} \left[ \left\lfloor \frac{n}{SF_{SCH2}} \right\rfloor \right] \\
 y_T[n] &= G_F W_{FCH}[n] D_{FCH} \left[ \left\lfloor \frac{n}{SF_{FCH}} \right\rfloor \right] + G_{S1} W_{SCH1}[n] D_{SCH1} \left[ \left\lfloor \frac{n}{SF_{SCH1}} \right\rfloor \right]
 \end{aligned}$$

Here  $\lfloor x \rfloor$  is a largest integer not greater than  $x$ .

The above mentioned Walsh code  $W_{PiCH}[n]$ ,  $W_{DCCH}[n]$ ,  $W_{SCH2}[n]$ ,  $W_{SCH1}[n]$ , and  $W_{FCH}[n]$  are orthogonal Walsh functions selected from  $H^{(SF_{PiCH})}, H^{(SF_{DCCH})}, H^{(SF_{SCH2})}, H^{(SF_{SCH1})}, H^{(SF_{FCH})}$ . An allocation method of the orthogonal Walsh functions to each channel with the orthogonal property follows the allocation method of the OVSF codes.  $SF_{PiCH}$ ,  $SF_{DCCH}$ ,  $SF_{SCH2}$ ,  $SF_{SCH1}$ , and  $SF_{FCH}$  are spreading factors for the corresponding channels.

For simple explanation, assume the transmitting power of SCH1 and SCH2 is assumed to be statistically greater than the power of PiCH, DCCH, and FCH. (This assumption does not change the present invention.) In other words, it is assumed the relation  $G_{S1} > G_P + G_D + G_F$ , and  $G_{S2} > G_P + G_D + G_F$ , holds statistically. The above assumptions hold in two cases: In the first case, the transmission data rate



for the supplementary channel (SCH1, SCH2) is greater than that of other channels (PICH, DCCH, FCH), and the required quality such as the signal-to-noise ratio (SNR) for each channel is comparable.

5 In the second case, the transmission data rates are comparable, and the required quality is more restricted. If there are only two channels available in a transmitter, the assumptions hold, and the two channels are allocated to SCH1 and SCH2. When the  
10 assumptions hold, EQUATION 10 can be approximated as EQUATION 11.

【EQUATION 11】

$$\begin{aligned} x_T[n] &\approx G_{S2} W_{SCH2}[n] D_{SCH2} \left[ \begin{array}{c} \bar{S}F_{SCH2}^n \\ \vdots \end{array} \right] \\ y_T[n] &\approx G_{S1} W_{SCH1}[n] D_{SCH1} \left[ \begin{array}{c} \bar{S}F_{SCH1}^n \\ \vdots \end{array} \right] \end{aligned}$$

The spreading modulation takes place at the  
15 Spreading Modulator (140) with the first inputs ( $x_T[n]$ ,  $y_T[n]$ ) and the second inputs, PN (Pseudo-Noise) sequences ( $C_1[n]$ ,  $C_2[n]$ ), and the outputs ( $I_T[n]$ ,  $Q_T[n]$ ) are produced. The peak transmission power to the average power ratio (PAR: Peak-to-  
20 Average Ratio) can be improved according to the

structure of the Spreading Modulator (140) and the method how to generate the scrambling codes ( $C_{\text{scramble}}$ ,  $i[n]$ ,  $C_{\text{scramble}}$ ,  $q[n]$ ) from the inputs of the two PN sequences ( $C_1[n]$ ,  $C_2[n]$ ). Conventional embodiments  
 5 for the Spreading Modulator (140) are shown in FIG. 3a ~ 3d. The outputs ( $I_T[n]$ ,  $Q_T[n]$ ) of the Spreading Modulator (140) pass through the low-pass-filters (160, 162) and the power amplifiers (170, 172). Then the amplified outputs are delivered to the  
 10 modulators (180, 182) which modulate the signals into the desired frequency band using carrier. And the modulated signals are added by the adder (190), and delivered to an antenna.

FIG. 2 shows a schematic diagram for a receiver  
 15 according to the transmitter of FIG. 1. The received signals passed through an antenna are demodulated at the demodulators (280, 282) with the same carrier used at the transmitter, and  $I_R[n]$  and  $Q_R[n]$  are generated after passing through the low-pas filters  
 20 (260, 262). Then, the spreading demodulator (240) generates the signals ( $x_R[n]$ ,  $y_R[n]$ ) with two PN sequences ( $C_1[n]$ ,  $C_2[n]$ ).

In order to pick up the desired channels, i.e., DCCH, FCH, SCH#1, SCH#2, among the received code division multiplexed signals  $(x_R[n], y_R[n])$ , the signals are multiplied by the same orthogonal code  $W_{xxCH}[n]$  (where,  $xxCH = DCCH$  or  $FCH$ ) or  $W_{yyCH}[n]$  (where,  $yyCH = SCH1$  or  $SCH2$ ) used at the transmitter, at the de-spreaders (224, 226, 225, 227). Now, the signals are integrated during the symbol period ( $T_{2x}$  or  $T_{2y}$ ) proportional to the data rate of the corresponding channel. Since the signals at the receiver are distorted, PiCH is used to correct the distorted signal phase. Therefore, the signals  $(x_R[n], y_R[n])$  are multiplied by the corresponding orthogonal code  $W_{PiCH}[n]$ , and are integrated during the period of  $T_1$  at the integrators (210, 212).

When the PiCH includes additional information such as a control command to control the transmitting power at the receiver, besides the pilot signals for the phase correction, the additional information is extracted by the de-multiplexer, and the phase is estimate and corrected using the part of the pilot signals with the known

phase. However, it is assumed that the PiCH does not include any additional information for simplicity. The phase corrections are performed at the second (kind) complex-domain multipliers (242, 246) using the estimated phase information through the integrators (210, 212). After selecting the output port according to the desired channel (DCCH, FCH, SCH1, or SCH2) at the second complex-domain multipliers (242, 246), the receiver recovers the transmitted data through the de-interleaver and/or the channel decoder (not shown in FIG. 2).

The first (143) and the second complex-domain multiplier (243 or 246) execute the following function.

#### 【EQUATION 12】

Operations for the first complex-domain multipliers (143, 145):

$$O_I[n] + jO_Q[n] = (x_I[n] + jx_Q[n])(y_I[n] + jy_Q[n])$$

$$O_I[n] = x_I[n]y_I[n] - x_Q[n]y_Q[n]$$

$$O_Q[n] = x_I[n]y_Q[n] + x_Q[n]y_I[n]$$

Operations for the second complex-domain multipliers

(242, 243, 245, 246):

$$O_I[n] + jO_Q[n] = (x_I[n] + jx_Q[n])(y_I[n] - jy_Q[n])$$

$$O_I[n] = x_I[n]y_I[n] + x_Q[n]y_Q[n]$$

$$O_Q[n] = -x_I[n]y_Q[n] + x_Q[n]y_I[n]$$

FIG. 7a and FIG. 7b show signal constellation diagrams. In FIG. 7a, a square represents the input  $(x_I[n] + jx_Q[n])$  of the first complex-domain multiplier, and a circle shows a normalized output  $(O_I[n] + jO_Q[n])$  of the first complex-domain multiplier. FIG. 7b shows four transitions  $(0, +\pi/2, -\pi/2, \pi)$  of the first complex-domain multiplier input  $(x_I[n] + jx_Q[n])$  according to the time flow. The PAR characteristic becomes worse at the origin crossing transition (or  $\pi$ -transition) in FIG. 7b.

FIG. 3a shows the schematic diagram for a conventional spreading modulator. This spreading modulation method is used in the forward link (from a base station to its mobile station) for a CDMA system of IS-95 method. This spreading modulation is called the QPSK (Quadrature Phase Shift Keying) spreading modulation.

[EQUATION 13]

$$I_T[n] = x_T[n] C_{\text{scramble}, I}[n]$$

$$Q_T[n] = y_T[n] C_{\text{scramble}, Q}[n]$$

The outputs ( $C_{\text{scramble}, I}[n]$ ,  $C_{\text{scramble}, Q}[n]$ ) of the secondary scrambling code generator shown in FIG. 4a are given by EQUATION 14. In other words, the secondary scrambling codes are the same as the primary scrambling codes.

【EQUATION 14】

$$C_{\text{scramble}, I}[n] = C_1[n]$$

$$C_{\text{scramble}, Q}[n] = C_2[n]$$

In the IS-95 system,  $x_T[n] = y_T[n]$ , but generally  $x_T[n] \neq y_T[n]$  in the QPSK spreading modulation. For  $|I_T[n]| = |Q_T[n]| = 1$  based on the normalization, the possible transitions of the signal constellation point occurring in the QPSK spreading modulation are shown in EQUATION 15. The probability for  $\{0, +\pi/2, -\pi/2, \pi\}$  transition is equally  $1/4$  for each transition.

【EQUATION 15】

$$\arg\left(\frac{I_T[n+1] + jQ_T[n+1]}{I_T[n] + jQ_T[n]}\right) \in \left\{0, +\frac{\pi}{2}, -\frac{\pi}{2}, \pi\right\}$$

FIG. 8a shows the transitions of the signal constellation point for the QPSK spreading modulation when  $I_T[n] = \pm 1$ ,  $Q_T[n] = \pm 1$ , and  $SF=4$ .

5 For  $n \equiv 0 \bmod SF$ ,  $(I_T[n], Q_T[n])$  becomes one of  $(+1, +1)$ ,  $(+1, -1)$ ,  $(-1, -1)$ ,  $(-1, +1)$  with an equal probability of  $1/4$ . The transition is assumed to start at  $(+1, +1)$ . There is no change in the signal constellation diagram at a chip time of  $n+1/2$ . At a  
10 chip time of  $n+1$ ,  $(I_T[n], Q_T[n])$  transits to one of  $(+1, +1)$ ,  $(+1, -1)$ ,  $(-1, -1)$ ,  $(-1, +1)$  with an equal probability of  $1/4$ . FIG. 8a shows the case of  $(+1, -1)$  transition.

There is no change in the signal constellation  
15 diagram at a chip time of  $n+3/2$ . At a chip time of  $n+2$ ,  $(I_T[n], Q_T[n])$  transits to one of  $(+1, +1)$ ,  $(+1, -1)$ ,  $(-1, -1)$ ,  $(-1, +1)$  with an equal probability of  $1/4$ . FIG. 8a shows the case of  $(-1, +1)$  transition. The PAR characteristic becomes worse in this case  
20 due to an origin crossing transition ( $\pi$ -transition).

There is no change in the signal constellation diagram at a chip time of  $n+5/2$ . At a chip time of  $n+3$ ,  $(I_T[n], Q_T[n])$  transits to one of  $(+1, +1)$ ,  $(+1, -1)$ ,  $(-1, -1)$ ,  $(-1, +1)$  with an equal probability of 1/4. FIG. 8a shows the case of  $(-1, -1)$  transition.

There is no change in the signal constellation diagram at a chip time of  $n+7/2$ . At a chip time of  $n+4$ ,  $(I_T[n], Q_T[n])$  transits to one of  $(+1, +1)$ ,  $(+1, -1)$ ,  $(-1, -1)$ ,  $(-1, +1)$  with an equal probability of 1/4. The above transition process is repeated according to the probability.

FIG. 3b shows a schematic diagram for another conventional spreading modulator. This spreading modulation method is used in the reverse link (from a mobile station to its base station) for the IS-95 CDMA system. This spreading modulation is called the OQPSK (Offset QPSK) spreading modulation, and the output signals are governed by EQUATION 16.

【EQUATION 16】

$$I_T[n] = x_T[n] C_{scramble, I}[n]$$

$$Q_T[n] = y_T\left[n - \frac{1}{2}\right] C_{scramble, Q}\left[n - \frac{1}{2}\right]$$



The outputs ( $C_{\text{scramble}, i}[n]$ ,  $C_{\text{scramble}, q}[n]$ ) of the secondary scrambling code generator in FIG. 4a are given by EQUATION 17. In other words, the secondary scrambling codes are the same as the primary scrambling codes, as in the previous QPSK spreading modulation.

【EQUATION 17】

$$C_{\text{scramble}, i}[n] = C_1[n]$$

$$C_{\text{scramble}, q}[n] = C_2[n]$$

Generally  $x_T[n] \neq y_T[n]$  in OQPSK spreading modulation. For  $|I_T[n]| = |Q_T[n]| = 1$  based on the normalization, the possible transitions of the signal constellation point occurring in the QPSK spreading modulation are shown in EQUATION 18. The probabilities for  $\{0, +\pi/2, -\pi/2, \pi\}$  transitions are  $1/2, 1/4, 1/4, 0$ , respectively.

【EQUATION 18】

$$\arg\left(\frac{I_T[n+1/2] + jQ_T[n+1/2]}{I_T[n] + jQ_T[n]}\right) \in \left\{0, +\frac{\pi}{2}, -\frac{\pi}{2}\right\}$$

$$\arg\left(\frac{I_T[n+1] + jQ_T[n+1]}{I_T[n+1/2] + jQ_T[n+1/2]}\right) \in \left\{0, +\frac{\pi}{2}, -\frac{\pi}{2}\right\}$$

In OQPSK spreading modulation shown in FIG. 3b, the signal of the orthogonal phase channel (Q-

channel) is delayed by a half chip ( $T_c/2$ ) relative to the signal of the in-phase channel (I-channel) in order to improve the PAR characteristic of QPSK spreading modulation in FIG. 3a. Due to a half chip  
 5 ( $T_c/2$ ) delay, the codes of the I-channel and Q-channel signals cannot be changed simultaneously. Thus, the  $\pi$ -transition crossing the origin is prohibited, and the PAR characteristic is improved.

FIG. 8b shows the transitions of the signal constellation point for the OQPSK spreading modulation when  $I_T[n] = \pm 1$ ,  $Q_T[n] = \pm 1$ , and  $SF=4$ . For  $n \equiv 0 \bmod SF$ ,  $(I_T[n], Q_T[n])$  becomes one of  $(+1, +1)$ ,  $(+1, -1)$ ,  $(-1, -1)$ ,  $(-1, +1)$  with an equal probability of  $1/4$ . The transition is assumed to  
 10 start at  $(+1, +1)$ . At a chip time of  $n+1/2$ ,  $(I_T[n], Q_T[n])$  transits to either  $(+1, +1)$  or  $(+1, -1)$  with an equal probability of  $1/2$ . FIG. 8b shows the case of  $(+1, +1)$  transition: At a chip time of  $n+1$ ,  $(I_T[n], Q_T[n])$  transits to either  $(+1, +1)$  or  $(-1, +1)$  with an equal probability of  $1/2$ . FIG. 8b shows the case of  $(+1, +1)$  transition: At a chip time of  $n+3/2$ ,  $(I_T[n], Q_T[n])$  transits to either  $(+1, +1)$  or

(+1, -1) with an equal probability of 1/2. FIG. 8b shows the case of (+1, -1) transition: At a chip time of  $n+2$ ,  $(I_T[n], Q_T[n])$  transits to either (+1, -1) or (-1, -1) with an equal probability of 1/2.

5 FIG. 8b shows the case of (-1, -1) transition: At a chip time of  $n+5/2$ ,  $(I_T[n], Q_T[n])$  transits to either (-1, -1) or (-1, +1) with an equal probability of 1/2. FIG. 8b shows the case of (-1, +1) transition: At a chip time of  $n+3$ ,  $(I_T[n], Q_T[n])$  transits to either (+1, +1) or (-1, +1) with an equal probability of 1/2. FIG. 8b shows the case of (-1, +1) transition: At a chip time of  $n+7/2$ ,  $(I_T[n], Q_T[n])$  transits to either (-1, +1) or (-1, -1) with an equal probability of 1/2. FIG. 8b shows the case of (-1, -1) transition: At a chip time of  $n+4$ ,  $(I_T[n], Q_T[n])$  transits to either (+1, -1) or (-1, -1) with an equal probability of 1/2. The above transition process is repeated according to the probability.

20 FIG. 3c shows a schematic diagram for another conventional spreading modulator. This spreading modulation method is subdivided into three methods

according to the scrambling code generator (150).  
 The first method is used in the forward link (from a  
 base station to its mobile station) for a W-CDMA  
 (Wideband CDMA) system as another candidate for  
 5 cdma2000 or IMT-2000 system. This spreading  
 modulation is called the CQPSK (Complex QPSK)  
 spreading modulation, and the output signals are  
 governed by EQUATION 19.

【EQUATION 19】

$$I_T[n] + jQ_T[n] = (x_T[n] + jy_T[n]) \left\{ \frac{1}{\sqrt{2}} (C_{scramble, I}[n] + jC_{scramble, Q}[n]) \right\}$$

$$I_T[n] = \frac{1}{\sqrt{2}} x_T[n] C_{scramble, I}[n] - \frac{1}{\sqrt{2}} y_T[n] C_{scramble, Q}[n]$$

$$Q_T[n] = \frac{1}{\sqrt{2}} x_T[n] C_{scramble, Q}[n] + \frac{1}{\sqrt{2}} y_T[n] C_{scramble, I}[n]$$

The outputs ( $C_{scramble, I}[n]$ ,  $C_{scramble, Q}[n]$ ) of the  
 secondary scrambling code generator in FIG. 4a are  
 given by EQUATION 20. In other words, the secondary  
 scrambling codes are the same as the primary  
 15 scrambling codes, as described in the previous QPSK  
 and OQPSK spreading modulation.

【EQUATION 20】

$$C_{scramble, I}[n] = C_1[n]$$

$$C_{scramble, Q}[n] = C_2[n]$$

Generally  $x_T[n] \neq y_T[n]$  in CQPSK spreading modulation. For  $|I_T[n]| = |Q_T[n]| = 1$  based on the normalization, the possible transitions of the signal constellation point occurring in the CQPSK spreading modulation are shown in EQUATION 21. The probability for  $\{0, +\pi/2, -\pi/2, \pi\}$  transition is equally 1/4 for each transition.

[EQUATION 21]

$$\arg \left\{ \frac{I_T[n+1] + jQ_T[n+1]}{I_T[n] + jQ_T[n]} \right\} \in \left\{ 0, +\frac{\pi}{2}, -\frac{\pi}{2}, \pi \right\}$$

The previous OQPSK method is effective when the I-channel and Q-channel powers are the same as in IS-95 reverse link channels. But the Q-channel signal should be delayed by a half chip, and the amplitude of the transmitting power for I-channel is different from that for Q-channel in the case of FIG. 1 when several channels with different transmitting powers are using orthogonal channels. The linear range of the amplifier should be selected based upon the largest transmitting signal power in order to reduce the neighboring channel interference from the signal distortion and the inter-modulation.

On the other hand, in CQPSK spreading modulation, I-channel signal ( $x_T[n]$ ) and Q-channel signal ( $y_T[n]$ ) are multiplied in complex-domain by the secondary scrambling codes,  $C_{\text{scramble},I}[n]$  and  $C_{\text{scramble},Q}[n]$  of the same amplitude. Therefore, the smaller of signal power level of the two (I and Q) become large, and the larger of signal power level of the two becomes small; the two signal power levels are equalized statistically. The CQPSK spreading modulation is more effective to improve the PAR characteristic when there are multiple channels with different power levels. In the CQPSK spreading modulation,  $x_T[n]+jy_T[n]$  makes an origin crossing transition ( $\pi$ -transition) with a probability of 1/4.

FIG. 8c shows the transitions of the signal constellation point for the CQPSK spreading modulation when  $x_T[n] = \pm 1$ ,  $y_T[n] = \pm 1$ ,  $I_T[n] = \pm 1$ ,  $Q_T[n] = \pm 1$ , and  $SF=4$ . For  $n \equiv 0 \pmod{SF}$ ,  $x_T[n]+jy_T[n]$  and  $C_{\text{scramble},I}[n]+jC_{\text{scramble},Q}[n]$  become one of  $1+j$ ,  $1-j$ ,  $-1-j$ ,  $-1+j$  with an equal probability of 1/4, and it is assumed that  $x_T[n]+jy_T[n]=1+j$  and

$C_{\text{scramble},I}[n] + jC_{\text{scramble},Q}[n] = 1 + j$  ; in other words, in  
 this case,  $I_T[n] + jQ_T[n] = 0 + j\sqrt{2}$  . And this equation  
 becomes  $I_T[n] + jQ_T[n] = 0 + j1$  due to the normalization.  
 There is no change in the signal constellation  
 5 diagram at a chip time of  $n+1/2$ . At a chip time of  
 $n+1$ ,  $x_T[n] + jy_T[n]$  transits to one of  $1+j$ ,  $1-j$ ,  $-1-j$ ,  
 and  $-1+j$ , and  $C_{\text{scramble},I}[n] + jC_{\text{scramble},Q}[n]$  also transits  
 to one of  $1+j$ ,  $1-j$ ,  $-1-j$ , and  $-1+j$ .

The second method is used in the reverse link  
 10 (from a mobile station to its base station) for a G-  
 CDMA (Global-CDMA) I and II systems as another  
 candidate for IMT-2000 system proposed at  
 International Telecommunications Union (ITU,  
<http://www.itu.int>) in June 1998. This spreading  
 15 modulation is called the OCQPSK (Orthogonal Complex  
 QPSK) spreading modulation referring to Korean  
 Patent NO. 10-269593-0000. The following relations  
 hold when only an even number is assigned to the  
 subscript of the orthogonal Walsh code for each  
 20 channel.

【EQUATION 22】

$$x_T[2n] \approx x_T[2n+1]$$

$$y_T[2n] \approx y_T[2n+1]$$

$$I_T[n] + jQ_T[n] = (x_T[n] + jy_T[n]) \left\{ \frac{1}{\sqrt{2}} (C_{scramble, I}[n] + jC_{scramble, Q}[n]) \right\}$$

$$I_T[n] = \frac{1}{\sqrt{2}} x_T[n] C_{scramble, I}[n] - \frac{1}{\sqrt{2}} y_T[n] C_{scramble, Q}[n]$$

$$Q_T[n] = \frac{1}{\sqrt{2}} x_T[n] C_{scramble, Q}[n] + \frac{1}{\sqrt{2}} y_T[n] C_{scramble, I}[n]$$

The outputs ( $C_{scramble, I}[n]$ ,  $C_{scramble, Q}[n]$ ) of the secondary scrambling code generator in FIG. 4b are given by EQUATION 23. Since  $W_0^{(p)}[n]=1$ , the secondary scrambling code generators in FIG. 4b and FIG. 4c are the same for  $k = 0$ .

【EQUATION 23】

$$C_{scramble, I}[n] + jC_{scramble, Q}[n] = C_1[n] (W_{2k}^{(p)}[n] + jW_{2k+1}^{(p)}[n])$$

$$C_{scramble, I}[n] = C_1[n] W_{2k}^{(p)}[n]$$

$$C_{scramble, Q}[n] = C_1[n] W_{2k+1}^{(p)}[n]$$

Where  $p$  is a power of 2 (i.e.,  $p = 2^n$ ), and

$$k \in \{0, 1, 2, \dots, \frac{p}{2} - 1\}$$

Generally  $x_T[n] \neq y_T[n]$  in OCQPSK spreading modulation. For  $|I_T[n]| = |Q_T[n]| = 1$  based on the normalization, the possible transitions of the



signal constellation point occurring in the OCQPSK spreading modulation are shown in EQUATION 24. The probabilities for  $\{0, +\pi/2, -\pi/2, \pi\}$  transitions are 0, 1/2, 1/2, and 0 for  $n=2t+1$  (odd number), and 1/4, 1/4, 1/4, and 1/4 in case of  $n=2t$  (even number) for each transition, respectively.

【EQUATION 24】

$$\begin{aligned}
 & \frac{I_T[n+1] + jQ_T[n+1]}{I_T[n] + jQ_T[n]} \\
 = & \frac{(x_T[n+1] + jy_T[n+1])(C_{\text{scramble}, I}[n+1] + jC_{\text{scramble}, Q}[n+1])}{(x_T[n] + jy_T[n])(C_{\text{scramble}, I}[n] + jC_{\text{scramble}, Q}[n])} \\
 = & \frac{x_T[n+1] + jy_T[n+1]}{x_T[n] + jy_T[n]} \cdot \frac{C_I[n+1](W_{2k}^{(p)}[n+1] + jW_{2k+1}^{(p)}[n+1])}{C_I[n](W_{2k}^{(p)}[n] + jW_{2k+1}^{(p)}[n])} \\
 & \arg\left\{\frac{I_T[2t+1] + jQ_T[2t+1]}{I_T[2t] + jQ_T[2t]}\right\} \in \left\{+\frac{\pi}{2}, -\frac{\pi}{2}\right\} \\
 & \arg\left\{\frac{I_T[2t+2] + jQ_T[2t+2]}{I_T[2t+1] + jQ_T[2t+1]}\right\} \in \left\{0, +\frac{\pi}{2}, -\frac{\pi}{2}, \pi\right\}
 \end{aligned}$$

10 In the OCQPSK spreading modulation, the following properties are used:

For  $W_{2k}^{(p)}[n]$ ,  $k \in \{0, 1, 2, \dots, \frac{P}{2} - 1\}$ ;  $W_{2k}^{(p)}[2t] = W_{2k}^{(p)}[2t+1]$ ,  
 $t \in \{0, 1, 2, \dots\}$ .

And for  $W_{2k+1}^{(p)}[n]$ ,  $k \in \{0, 1, 2, \dots, \frac{P}{2} - 1\}$ ;  $W_{2k+1}^{(p)}[2t] = -$

$$W_{2k+1}^{(p)}[2t+1], \quad t \in \{0, 1, 2, \dots\}.$$

The orthogonal Walsh codes with even number subscripts are used for the channel identification except for the case when the orthogonal Walsh codes with odd number subscripts must be used for the channel identification due to the high transmitting data rate. Because  $x_T[2t] = x_T[2t+1]$ ,  $y_T[2t] = y_T[2t+1]$ ,  $t \in \{0, 1, 2, \dots\}$ , the following approximation holds as described in EQUATION 25.

【EQUATION 25】

$$x_T[n] + jy_T[n] \approx G_{S2} W_{SCH2}[n] D_{SCH2} \left[ \left\lfloor \frac{n}{SF_{SCH2}} \right\rfloor \right] + jG_{S1} W_{SCH1}[n] D_{SCH1} \left[ \left\lfloor \frac{n}{SF_{SCH1}} \right\rfloor \right]$$

In the OCQPSK spreading modulation, avoiding the origin crossing transition ( $\pi$ -transition) which makes worse the PAR characteristic for  $n=2t+1$ , the PAR characteristic of the spreading signals is improved compared to the CQPSK spreading modulation. At  $n=2t$ ,  $x_T[n] + jy_T[n]$  makes an origin crossing transition ( $\pi$ -transition) with a probability of 1/4 as in the CQPSK spreading modulation, while, at  $n=2t+1$ , the corresponding probability is zero. Therefore, the average probability for the origin

crossing transition ( $\pi$ -transition) decreases to 1/8 from 1/4.  $C_1[n]$  for the scrambling in FIG. 4b is also used in identifying the transmitter.

The third method is used in the reverse link (from a mobile station to its base station) for a W-CDMA system as another candidate for cdma2000 and IMT-2000 system. This spreading modulation is POCQPSK (Permuted Orthogonal Complex QPSK) spreading modulation referring to Korean Patent NO. 10-269593-0000. The following relations hold when only an even number is assigned to the subscript of the orthogonal Walsh code for each channel.

【EQUATION 26】

$$x_T[2n] \approx x_T[2n+1]$$

$$y_T[2n] \approx y_T[2n+1]$$

$$I_T[n] + jQ_T[n] = (x_T[n] + jy_T[n]) \left\{ \frac{1}{\sqrt{2}} (C_{scramble, I}[n] + jC_{scramble, Q}[n]) \right\}$$

$$I_T[n] = \frac{1}{\sqrt{2}} x_T[n] C_{scramble, I}[n] - \frac{1}{\sqrt{2}} y_T[n] C_{scramble, Q}[n]$$

$$Q_T[n] = \frac{1}{\sqrt{2}} x_T[n] C_{scramble, Q}[n] + \frac{1}{\sqrt{2}} y_T[n] C_{scramble, I}[n]$$

The outputs ( $C_{scramble, I}[n]$ ,  $C_{scramble, Q}[n]$ ) of the secondary scrambling code generator in FIG. 4d are given by EQUATION 27.

## 【EQUATION 27】

$$\begin{aligned}
C_{scramble,I}[n] + jC_{scramble,Q}[n] &= C_1[n] (W_{2k}^{(\rho)}[n] + jC_2[n] W_{2k+1}^{(\rho)}[n]) \\
C_{scramble,I}[n] &= C_1[n] W_{2k}^{(\rho)}[n] \\
C_{scramble,Q}[n] &= C_1[n] C_2[n] W_{2k+1}^{(\rho)}[n] \\
C_2[2t] &= C_2[2t+1] = C_2[2t], \quad t \in \{0, 1, 2, \dots\}
\end{aligned}$$

Generally  $x_T[n] \neq y_T[n]$  in POCQPSK spreading modulation. For  $|I_T[n]| = |Q_T[n]| = 1$  based on the normalization, the possible transitions of the signal constellation point occurring in the POCQPSK spreading modulation are shown in EQUATION 28. The probabilities for  $\{0, +\pi/2, -\pi/2, \pi\}$  transition is 0, 1/2, 1/2, and 0 for  $n=2t+1$  (odd number), and 1/4, 1/4, 1/4, and 1/4 in case of  $n=2t$  (even number) for each transition, respectively.

## 【EQUATION 28】

$$\begin{aligned}
& \frac{I_T[2t+1] + jQ_T[2t+1]}{I_T[2t] + jQ_T[2t]} \\
&= \frac{x_T[2t+1] + jy_T[2t+1]}{x_T[2t] + jy_T[2t]} \cdot \frac{C_{scramble, I}[2t+1] + jC_{scramble, Q}[2t+1]}{C_{scramble, I}[2t] + jC_{scramble, Q}[2t]} \\
&= \frac{C_1[2t+1]}{C_1[2t]} \cdot \frac{W_{2k}^{(p)}[2t+1] + jC_2[2t+1]W_{2k+1}^{(p)}[2t+1]}{W_{2k}^{(p)}[2t] + jC_2[2t]W_{2k+1}^{(p)}[2t]} \\
&= \frac{C_1[2t+1]}{C_1[2t]} \cdot \frac{1 - jC_2[2t]W_1^{(p)}[2t]}{1 + jC_2[2t]W_1^{(p)}[2t]}
\end{aligned}$$

$$\arg \left\{ \frac{I_T[2t+1] + jQ_T[2t+1]}{I_T[2t] + jQ_T[2t]} \right\} \in \left\{ +\frac{\pi}{2}, -\frac{\pi}{2} \right\}$$

$$\begin{aligned}
& \frac{I_T[2t+2] + jQ_T[2t+2]}{I_T[2t+1] + jQ_T[2t+1]} \\
&= \frac{(x_T[2t+2] + jy_T[2t+2])(C_{scramble, I}[2t+2] + jC_{scramble, Q}[2t+2])}{(x_T[2t+1] + jy_T[2t+1])(C_{scramble, I}[2t+1] + jC_{scramble, Q}[2t+1])} \\
&= \frac{x_T[2t+2] + jy_T[2t+2]}{x_T[2t+1] + jy_T[2t+1]} \cdot \frac{W_{2k}^{(p)}[2t+2]}{W_{2k}^{(p)}[2t+1]} \cdot \frac{C_1[2t+2]}{C_1[2t+1]} \cdot \frac{1 + jC_2[2t+2]W_1^{(p)}[2t+2]}{1 + jC_2[2t+1]W_1^{(p)}[2t+1]}
\end{aligned}$$

$$\arg \left\{ \frac{I_T[2t+2] + jQ_T[2t+2]}{I_T[2t+1] + jQ_T[2t+1]} \right\} \in \left\{ 0, +\frac{\pi}{2}, -\frac{\pi}{2}, \pi \right\}$$

The POCQPSK spreading modulation is basically the same as the OCQPSK spreading modulation. Therefore, at  $n=2t$ ,  $x_T[n] + jy_T[n]$  makes an origin crossing transition ( $\pi$ -transition) with a probability of 1/4 as described in the CQPSK spreading modulation, while, at  $n=2t+1$ , the corresponding probability is zero.  $C'_2[n]$  decimated from  $C_2[n]$  is used in order to compensate for the lack of the randomness due to a periodic repetition of the orthogonal Walsh functions. The decimation should be made with the following properties:

For  $t \in \{0, 1, 2, \dots\}$  and  $k \in \{0, 1, 2, \dots, \frac{P}{2} - 1\}$ ,

$$W_{2k+1}^{(P)}[2t] = -W_{2k+1}^{(P)}[2t+1], \text{ and } C'_2[2t] W_{2k+1}^{(P)}[2t] \\ = -C'_2[2t+1] W_{2k+1}^{(P)}[2t+1].$$

Even though  $C_2[n]$  is decimated to 2:1 in the above  
 5 case,  $2^d:1$  decimation for  $d \in \{1, 2, 3, \dots\}$  is also  
 possible. When  $2^d = \max\{SF_{PICH}, SF_{DCCCH}, SF_{SCH2}, SF_{SCH1},$   
 $SF_{FCH}\}$ , the randomness of the POCQPSK is the same as  
 that of the OCQPSK, and the randomness becomes high  
 for 2:1 decimation with  $d=1$ .  $C_1[n]$  and  $C_2[n]$  for the  
 10 scrambling to obtain the better spectrum  
 characteristic are also used to identify the  
 transmitter through the auto-correlation and the  
 cross-correlation. The number of identifiable  
 transmitters increases when both of  $C_1[n]$  and  $C_2[n]$   
 15 are used as the scrambling codes.

FIG. 9 and FIG. 10 show schematic diagrams for  
 a transmitter and a receiver using the POCQPSK  
 spreading modulation. FIG. 9 shows a schematic  
 diagram for the transmitter based on the cdma2000  
 20 system, which is one of the candidates for IMT-2000  
 system as a third generation mobile communication

system. The transmitter has five orthogonal channels: PICH, DCCH, FCH, SCH1, and SCH2. Each channel performs the signal conversion process by changing a binary data {0, 1} into {+1, -1}.

5 The gain controlled signal for each channel is spread at the spreader (120, 122, 124, 126, 128) with the orthogonal OVSF code  $W_{PICH}[n]$ ,  $W_{DCCH}[n]$ ,  $W_{SCH2}[n]$ ,  $W_{SCH1}[n]$ , or  $W_{FCH}[n]$ , and is delivered to the adder (130, 132). The spreading modulation takes  
 10 place at the Spreading Modulator (140) with the first inputs ( $x_T[n]$ ,  $y_T[n]$ ) and the second inputs (the primary scrambling codes;  $C_1[n]$  and  $C_2[n]$ ), and the outputs ( $I_T[n]$ ,  $Q_T[n]$ ) are generated. The spreading modulator (140) comprises the scrambling  
 15 code generator (510) and the first complex-domain multiplier (143). The scrambling code generator (510) produces the secondary scrambling codes ( $C_{scramble, i}[n]$ ,  $C_{scramble, q}[n]$ ) with the primary scrambling codes ( $C_1[n]$ ,  $C_2[n]$ ) as the inputs to  
 20 improve the PAR characteristic. The first complex-domain multiplier (143) takes  $x_T[n]$  and  $y_T[n]$  as inputs and the secondary scrambling codes ( $C_{scramble, i}[n]$ ,  $C_{scramble, q}[n]$ ) as the inputs.

$i[n]$ ,  $C_{\text{scramble}, q}[n]$ ) as another inputs.

The primary scrambling codes ( $C_1[n]$ ,  $C_2[n]$ ) in the cdma2000 system is produced by the primary scrambling code generator (550) using three PN sequences ( $PN_I[n]$ ,  $PN_Q[n]$ ,  $PN_{\text{long}}[n]$ ) as shown in FIG. 5a with the following equation:

【EQUATION 29】

$$C_1[n] = PN_I[n] PN_{\text{long}}[n]$$

$$C_2[n] = PN_Q[n] PN_{\text{long}}[n-1]$$

The secondary scrambling codes ( $C_{\text{scramble}, i}[n]$ ,  $C_{\text{scramble}, q}[n]$ ) are given by the following equation:

【EQUATION 30】

$$C_{\text{scramble}, i}[n] = C_1[n] W_0^{(p)}[n] = C_1[n]$$

$$C_{\text{scramble}, q}[n] = C_1[n] C_2[n] W_1^{(p)}[n]$$

$$C_2[2t] = C_2[2t+1] = C_2[2t], \quad t \in \{0, 1, 2, \dots\}$$

The outputs ( $I_T[n]$ ,  $Q_T[n]$ ) of the Spreading Modulator (140) pass through the low-pass filters (160, 162) and power amplifiers (170, 172). Then the amplified outputs are delivered to the modulators (180, 182) which modulate the signals into the desired frequency band using a carrier. And the



modulated signals are added by the adder (190), and delivered to an antenna.

FIG. 10 shows a schematic diagram for a receiver according to the transmitter of FIG. 9. The received signals through an antenna are demodulated at the demodulators (280, 282) with the same carrier used at the transmitter, and  $I_R[n]$  and  $Q_R[n]$  are generated after the signals pass through the low-pass filters (260, 262). Then, the spreading demodulator (240) produces the signals ( $x_R[n]$ ,  $y_R[n]$ ) with the primary scrambling codes ( $C_1[n]$ ,  $C_2[n]$ ). The spreading demodulator (240) comprises the scrambling code generator (510) and the second complex-domain multiplier (243). The scrambling code generator (510) produces the secondary scrambling codes ( $C_{scramble, i}[n]$ ,  $C_{scramble, q}[n]$ ) with the primary scrambling codes ( $C_1[n]$ ,  $C_2[n]$ ) as the inputs to improve the PAR characteristic. The second complex-domain multiplier (243) in the spreading demodulator (240) takes the  $I_R[n]$ ,  $Q_R[n]$  as the first inputs and the secondary scrambling codes ( $C_{scramble, i}[n]$ ,  $C_{scramble, q}[n]$ ) as the second inputs. The first and

secondary scrambling codes are generated by the same method as in the transmitter.

In order to select the desired channels among the outputs  $(x_R[n], y_R[n])$  of the spreading demodulator (240), the signals are multiplied by the same orthogonal code  $W_{xxCH}[n]$  (where,  $xxCH = DCCH$  or FCH) or  $W_{yyCH}[n]$  (where,  $yyCH = SCH1$  or SCH2) used at the transmitter, at the despreaders (224, 226, 225, 227). Then, the signals are integrated during the symbol period  $T_{2x}$  or  $T_{2y}$ . Since the signals at the receiver are distorted, PiCH is used to correct the distorted signal phase. Therefore, the signals  $(x_R[n], y_R[n])$  are multiplied by the corresponding orthogonal code  $W_{PiCH}[n]$ , and are integrated during the period of  $T_1$  at the integrators (210, 212).

The reverse link PiCH in the cdma2000 system may include additional information such as a control command to control the transmitting power at the receiver, besides the pilot signals for the phase correction. In this case, the additional information is extracted by the de-multiplexer, and the phase is estimated using the part of the pilot signals having

the known phase. The phase corrections are performed at the second (kind) complex-domain multipliers (242, 246) shown in the left of FIG. 10 using the estimated phase information through the integrators (210, 212).

However, the conventional CDMA systems have two problems: The first problem is that the strict condition for the linearity of the power amplifier is required. The second problem is when there are several transmitting channels, the signal distortion and the neighboring frequency interference should be reduced. Therefore, the expensive power amplifiers with the better linear characteristic are required.

## 15 DISCLOSURE OF THE INVENTION

The object of this invention is to provide a method and an apparatus for the spreading modulation method in CDMA spread spectrum communication systems to solve the above mentioned problems. In the spreading modulation method according to this invention, the probability for the spread signals

( $x_T[n] + jy_T[n]$ ) to make the origin crossing transition ( $\pi$ -transition) becomes zero not only at  $n=2t+1$ ,  $t \in \{0, 1, 2, \dots\}$  as in cases of the OCQPSK and POCQPSK spreading modulation but also at  $n=2t$  only except for the time  $n \equiv 0 \pmod{\min\{SF_{PICH}, SF_{DCCH}, SF_{SCH2}, SF_{SCH1}, SF_{FCH}\}}$  when the spread transmitting data vary. Therefore, the PAR characteristic is improved by using the proposed spreading modulation scheme. In other words, this invention provides a method and an apparatus for the spreading modulation method with improved PAR characteristic in CDMA spread spectrum communication systems.

In accordance with an aspect of this invention an apparatus and a method for spreading modulation are invented in CDMA systems with a transmitter and receivers.

The transmitter according to the proposed invention has several channels with different information. Each channel spreads with the orthogonal codes using a complex-domain multiplier in addition to the conventional spreaders, and the spread signals are added. Then the signals are

scrambled with the PN sequences, are modulated with a carrier, and are delivered to an antenna.

The receiver according to the invention demodulates the received signals with the same carrier used in the transmitter. The demodulated mixed signals are de-scrambled with the same synchronized PN sequences, and the de-scrambled signals are de-spread with the same synchronized orthogonal codes using a complex-domain multiplier in addition to the conventional de-spreaders. Then the desired information is recovered at the receiver with the conventional signal processing.

In a preferred embodiment, the transmitter according to the invention has an additional complex-domain multiplier and a special scrambling code generator. The probability for the spread signals  $(x_T[n] + jy_T[n])$  to make the origin crossing transition ( $\pi$ -transition) becomes zero not only for  $n=2t+1$ ,  $t \in \{0, 1, 2, \dots\}$  but also for  $n=2t$  only except for the time  $n \equiv 0 \pmod{\min\{SF_{P1CH}, SF_{DCCN}, SF_{SCH2}, SF_{SCH1}, SF_{FCH}\}}$  when the spread transmitting data vary.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Exemplary embodiments of the present invention will be described in conjunction with the drawings in which:

FIG. 1 shows a schematic diagram for a conventional CDMA transmitter with orthogonal multiple channels;

FIG. 2 shows a schematic diagram for a receiver according to the transmitter of FIG. 1;

FIG. 3a shows a schematic diagram for a conventional QPSK spreading modulator;

FIG. 3b shows a schematic diagram for a conventional OQPSK spreading modulator;

FIG. 3c shows a schematic diagram for a conventional CQPSK, OCQPSK, POCQPSK spreading modulator and for a spreading modulator according to the present invention;

FIG. 3d shows another schematic diagram for a conventional OCQPSK, POCQPSK spreading modulator;

FIG. 4a shows a schematic diagram for the scrambling code generator in the QPSK, OQPSK, CQPSK

spreading modulation;

FIG. 4b shows a schematic diagram for the scrambling code generator in the OCQPSK spreading modulation;

5 FIG. 4c shows another schematic diagram for the scrambling code generator in the OCQPSK spreading modulation;

10 FIG. 4d shows a schematic diagram for the scrambling code generator in the POCQPSK spreading modulation;

FIG. 5a shows schematic diagrams for the first and secondary scrambling code generators in the cdma2000 modulation;

15 FIG. 5b shows a general diagram for the secondary scrambling code generator in FIG. 5a;

FIG. 6a shows a schematic diagram for a conventional CQPSK, OCQPSK, POCQPSK spreading demodulator and for a spreading demodulator according to the present invention;

20 FIG. 6b shows a schematic diagram for a conventional OCQPSK, POCQPSK spreading demodulator;

FIG. 7a shows a signal constellation diagram

and transitions;

FIG. 7b shows four possible transitions of a signal constellation point;

FIG. 8a shows the transitions of a signal constellation point for the QPSK spreading modulation;

FIG. 8b shows the transitions of a signal constellation point for the OQPSK spreading modulation;

FIG. 8c shows the transitions of a signal constellation point for the CQPSK spreading modulation;

FIG. 9 shows a schematic diagram for a cdma2000 transmitter;

FIG. 10 shows a schematic diagram for a cdma2000 receiver according to the transmitter of FIG. 9;

FIG. 11a shows a schematic diagram for a transmitter according to the present invention;

FIG. 11b shows a schematic diagram for the scrambling code generator in the DCQPSK spreading modulation according to the present invention; and



FIG. 12 shows a schematic diagram for a receiver according to the transmitter of FIG. 11a.

<Explanations for main symbols in the drawings>

5 110, 112, 114, 116, 118: gain controller  
120, 122, 124, 126, 128: spreader  
130, 132: adder  
140, 141: spreading modulator  
143, 145: first (kind) complex(-domain) multiplier  
10 150, 151: scrambling code generator  
160, 162: low-pass filter (LPF)  
170, 172: power amplifier  
180, 182: modulator  
190: adder  
15 210, 212, 214, 215, 216, 217: integrator  
220, 222, 224, 226, 225, 227: de-spreader  
240, 241: spreading demodulator  
242, 243, 245, 246: second (kind) complex(-domain)  
multiplier  
20 260, 262: low-pass filter  
280, 282: demodulator  
510, 520, 530, 550: scrambling code generator

1220, 1222, 1224, 1226: de-spreader

#### BEST MODE FOR CARRYING OUT THE INVENTION

5           The present invention will be better understood with regard to the following description, appended claims, and accompanying figures. In this application, similar reference numbers are used for components similar to the prior art and the modified or added components in comparison with the prior art are described for the present invention in detail.

10           FIG. 11 and FIG. 12 show schematic diagram for a transmitter and a receiver according to the present invention, respectively. The transmitter in FIG. 11a and the receiver in FIG. 12 are modified from the transmitter and the receiver with the POCQPSK spreading modulation shown in FIG. 9 and FIG. 10. The transmitter according to the invention has 5 orthogonal channels: PICH, DCCH, FCH, SCH1, and SCH2.

20           Unlike the previous transmitter as in FIG. 9, the transmitter according to the invention has an additional complex-domain multiplier (145) shown in

the left of FIG. 11a. The complex-domain multiplier

(145) takes the transmitting data ( $D_{SCH1}[\frac{n}{SF_{SCH1}}]$ ,

$D_{SCH2}[\frac{n}{SF_{SCH2}}]$ ) of SCH1 and SCH2 of statistically high

transmitting power as the first inputs and takes the

5 orthogonal OVSF codes ( $H_{SCH1}[n]$ ,  $H_{SCH2}[n]$ ) as the

second inputs. And the first orthogonal complex-

domain spreading occurs at the complex-domain

multiplier (145). Other gain-controlled signals for

PICH, DCCH and FCH spread at the spreaders (1120,

10 1122, 1128) with orthogonal OVSF codes ( $H_{PICH}[n]$ ,

$H_{DCCH}[n]$ ,  $H_{FCH}[n]$ ), and are delivered to the adders

(130, 132) with the outputs ( $S_I[n]$ ,  $S_Q[n]$ ) of the

complex-domain multiplier (145). The outputs ( $x_T[n]$ ,

$y_T[n]$ ) of the adder (130, 132) are given in EQUATION

15 31.

【EQUATION 31】

$$\begin{aligned}
x_T[n] &= G_P H_{PCH}[n] D_{PCH}\left[\left\lfloor \frac{n}{SF_{PCH}} \right\rfloor\right] + G_D H_{DCCH}[n] D_{DCCH}\left[\left\lfloor \frac{n}{SF_{DCCH}} \right\rfloor\right] \\
&\quad + \frac{1}{\sqrt{2}} G_{S1} H_{SCH1}[n] D_{SCH1}\left[\left\lfloor \frac{n}{SF_{SCH1}} \right\rfloor\right] - \frac{1}{\sqrt{2}} G_{S2} H_{SCH2}[n] D_{SCH2}\left[\left\lfloor \frac{n}{SF_{SCH2}} \right\rfloor\right] \\
&\approx \frac{1}{\sqrt{2}} G_{S1} H_{SCH1}[n] D_{SCH1}\left[\left\lfloor \frac{n}{SF_{SCH1}} \right\rfloor\right] - \frac{1}{\sqrt{2}} G_{S2} H_{SCH2}[n] D_{SCH2}\left[\left\lfloor \frac{n}{SF_{SCH2}} \right\rfloor\right] \\
y_T[n] &= G_F H_{FCH}[n] D_{FCH}\left[\left\lfloor \frac{n}{SF_{FCH}} \right\rfloor\right] \\
&\quad + \frac{1}{\sqrt{2}} G_{S2} H_{SCH1}[n] D_{SCH2}\left[\left\lfloor \frac{n}{SF_{SCH2}} \right\rfloor\right] + \frac{1}{\sqrt{2}} G_{S1} H_{SCH2}[n] D_{SCH1}\left[\left\lfloor \frac{n}{SF_{SCH1}} \right\rfloor\right] \\
&\approx \frac{1}{\sqrt{2}} G_{S2} H_{SCH1}[n] D_{SCH2}\left[\left\lfloor \frac{n}{SF_{SCH2}} \right\rfloor\right] + \frac{1}{\sqrt{2}} G_{S1} H_{SCH2}[n] D_{SCH1}\left[\left\lfloor \frac{n}{SF_{SCH1}} \right\rfloor\right]
\end{aligned}$$

The spreading modulation takes place at the Spreading Modulator (141) with the first inputs ( $x_T[n]$ ,  $y_T[n]$ ) and the second inputs (the primary scrambling codes;  $C_1[n]$  and  $C_2[n]$ ), and the outputs ( $I_T[n]$ ,  $Q_T[n]$ ) are generated. The spreading modulator (141) comprises the scrambling code generator (530) and the complex-domain multiplier (143). The scrambling code generator (530) according to the present invention shown in FIG. 11b generates the secondary scrambling codes ( $C_{scramble, i}[n]$ ,  $C_{scramble, q}[n]$ ) with the primary scrambling codes ( $C_1[n]$ ,  $C_2[n]$ ) as the inputs to improve the PAR characteristic. The complex-domain multiplier (143) takes the  $x_T[n]$ ,  $y_T[n]$  as inputs and the secondary

scrambling codes ( $C_{\text{scramble}, I}[n]$ ,  $C_{\text{scramble}, Q}[n]$ ) as another inputs. The primary scrambling codes ( $C_1[n]$ ,  $C_2[n]$ ) in the cdma2000 system are generated by the primary scrambling code generator (550) using three  
 5 PN sequences ( $PN_I[n]$ ,  $PN_Q[n]$ ,  $PN_{\text{long}}[n]$ ) as shown in FIG. 5a with the following equation:

【EQUATION 32】

$$C_1[n] = PN_I[n] PN_{\text{long}}[n]$$

$$C_2[n] = PN_Q[n] PN_{\text{long}}[n-1]$$

The secondary scrambling codes ( $C_{\text{scramble}, I}[n]$ ,  $C_{\text{scramble}, Q}[n]$ ) shown in FIG. 11b are given by the  
 10 following equations.

(1) For  $n \equiv 0 \pmod{\min\{SF_{PICH}, SF_{DCCH}, SF_{SCH2}, SF_{SCH1}, SF_{FCH}\}}$

【EQUATION 33】

$$C_{\text{scramble}, I}[n] = C_1[n]$$

$$C_{\text{scramble}, Q}[n] = C_2[n]$$

$$\arg \left\{ \frac{I_T[n] + jQ_T[n]}{I_T[n-1] + jQ_T[n-1]} \right\} \in \left\{ 0, +\frac{\pi}{2}, -\frac{\pi}{2}, \pi \right\}$$

(2) For  $n \not\equiv 0 \pmod{\min\{SF_{PICH}, SF_{DCCH}, SF_{SCH2}, SF_{SCH1}, SF_{FCH}\}}$

## 【EQUATION 34】

$$\begin{aligned}
& C_{\text{scramble},I}[n] + jC_{\text{scramble},Q}[n] \\
& = jC_2[n] \{ C_{\text{scramble},I}[n-1]H_{\text{SCH1}}[n-1]H_{\text{SCH1}}[n] \\
& \quad + jC_{\text{scramble},Q}[n-1]H_{\text{SCH2}}[n-1]H_{\text{SCH2}}[n] \} \\
& C_{\text{scramble},I}[n] = -C_2[n]C_{\text{scramble},Q}[n-1]H_{\text{SCH2}}[n-1]H_{\text{SCH2}}[n] \\
& C_{\text{scramble},Q}[n] = C_2[n]C_{\text{scramble},I}[n-1]H_{\text{SCH1}}[n-1]H_{\text{SCH1}}[n]
\end{aligned}$$

The spreading modulation according to the present invention is called the DCQPSK (Double Complex QPSK) spreading modulation. For  $|I_T[n]| = |Q_T[n]| = 1$  based on the normalization, the possible transitions of the signal constellation point occurring in the DCQPSK spreading modulation are shown in EQUATION 35 and EQUATION 36. The probabilities for  $\{0, +\pi/2, -\pi/2, \pi\}$  transitions are  $1/4, 1/4, 1/4,$  and  $1/4$  for  $n \equiv 0 \bmod SF_{\min}$ , and  $0, 1/2, 1/2,$  and  $0$  when  $n \not\equiv 0 \bmod SF_{\min}$  for each transition, respectively. Here,  $SF_{\min} = \min\{SF_{\text{PICH}}, SF_{\text{DCCH}}, SF_{\text{SCH2}}, SF_{\text{SCH1}}, SF_{\text{FCH}}\}$ .

(1) For  $n \equiv 0 \bmod SF_{\min}$

## 【EQUATION 35】



(exclusive OR) operation in EQUATION 6,  $(a)_2 = (SCH1)_2 \oplus (SCH2)_2$ .

In the OCQPSK or POCQPSK spreading modulation, as mentioned earlier, the orthogonal Walsh codes with even number subscripts are used except for the inevitable cases such as the case with the high transmitting data rate for a certain channel of spreading factor (SF) of 2. However, the DCQPSK spreading modulation supports the variable spreading factor keeping the orthogonal channel property with any orthogonal codes as shown in the previous equations. Thus the orthogonal code is represented by "H" instead of "W" representing the orthogonal Walsh code. The spreading factor (SF) or size of the orthogonal code need not be the power of 2.

The outputs  $(I_T[n], Q_T[n])$  of the Spreading Modulator (141) pass through the low-pass filters (160, 162) and the amplifiers (170, 172). Then the amplified outputs are delivered to the modulators (180, 182) which modulate the signals into the desired frequency band using a carrier. And the modulated signals are added by the adder (190), and



delivered to an antenna.

FIG. 12 shows a schematic diagram for a receiver according to the transmitter of FIG. 11a. The received signals through the antenna are demodulated at the demodulators (280, 282) with the same carrier used at the transmitter, and  $I_R[n]$  and  $Q_R[n]$  are generated after the signals pass through the low-pass filters (260, 262). Then, the spreading demodulator (241) produces the signals ( $x_R[n]$ ,  $y_R[n]$ ) with the primary scrambling codes ( $C_1[n]$ ,  $C_2[n]$ ). The spreading demodulator (241) comprises the scrambling code generator (530) and the complex-domain multiplier (243). The scrambling code generator (520) produces the secondary scrambling codes ( $C_{scramble, i}[n]$ ,  $C_{scramble, q}[n]$ ) with the primary scrambling codes ( $C_1[n]$ ,  $C_2[n]$ ) as the inputs to improve the PAR characteristic. The complex-domain multiplier (243) takes  $I_R[n]$  and  $Q_R[n]$  as the first inputs and the secondary scrambling codes ( $C_{scramble, i}[n]$ ,  $C_{scramble, q}[n]$ ) as the second inputs. The first and secondary scrambling codes are generated by the same method as in the transmitter.

In order to pick up the desired channels among the outputs  $(x_R[n], y_R[n])$  of the spreading demodulator (241), the signals are multiplied by the same orthogonal code  $H_{xxCH}[n]$  (where,  $xxCH = DCCH$  or FCH) used in the transmitter, at the de-spreaders (1224, 1226) or the signal are multiplied in complex-domain at the complex-domain multiplier (245) in FIG. 12 with the same orthogonal code  $H_{xxCH}[n]$  (where,  $xxCH = SCH1$  or  $SCH2$ ) used in the transmitter. Now, the signals are integrated during the symbol period  $T_{2x}$  or  $T_{2y}$ . Since the signals at the receiver are distorted,  $PiCH$  is used to correct the distorted signal phase. Accordingly, the signals  $(x_R[n], y_R[n])$  are multiplied by the corresponding orthogonal code  $H_{PiCH}[n]$ , and are integrated during the period of  $T_1$  at the integrators (210, 212).

The reverse link  $PiCH$  in the cdma2000 system may include additional information such as a control command to control the transmitting power at the receiver, besides the pilot signals for the phase correction. In this case, the additional information is extracted by the de-multiplexer, and the phase is

estimated using the part of the pilot signals having the known phase. The phase corrections are performed at the complex-domain multipliers (242, 246) using the estimated phase information through the  
5 integrators (210, 212).

The DCQPSK spreading modulation according to the present invention yields the following effects: First, the PAR characteristic is improved because the probability of the origin crossing transition  
10 ( $\square$ -transition) becomes zero only except for the time when the spread transmitting data vary. Second, the flexibility for the channel allocation becomes better because the DCQPSK can use all orthogonal codes while the OCQPSK or POCQPSK should use the  
15 orthogonal Walsh codes with even number subscripts.

While the foregoing invention has been described in terms of the embodiments discussed above, numerous variations are also possible. Accordingly, modifications and changes such as those  
20 suggested above, but not limited thereto, are considered to be within the scope of the following claims.

**WHAT IS CLAIMED IS:**

1. A transmitting method in CDMA (Code Division  
5 Multiple Access) systems with a transmitting  
apparatus and receiving apparatus, comprising the  
steps of:

(a) generating a pilot signal and transmitting data  
signals for several channels with different  
10 information; (b) spreading the signal using a  
orthogonal code for each channel; (c) adding the  
spread signals; (d) scrambling the added signals  
using PN (Pseudo-Noise) sequences; (e) modulating  
the scrambled signals with carrier; and (f)  
15 transmitting a composite signal created by adding  
the modulated signals.

2. A transmitting method as defined in claim 1,  
wherein the spreading step and the scrambling step  
perform an orthogonal complex-domain spreading and a  
20 complex-domain scrambling, respectively, in order to  
improve the PAR (Peak-to-Average power Ratio)  
characteristic of the transmitter.

3. A transmitting method as defined in claim 2,  
 wherein the second complex-domain scrambling codes  
 $(C_{\text{scramble}, I}[n], C_{\text{scramble}, Q}[n])$  in the scrambling step  
 are given by the following equations in terms of the  
 5 primary scrambling codes  $(C_1[n], C_2[n])$ :

(a) when the spreading data vary,

【EQUATION 37】

$$C_{\text{scramble}, I}[n] + j C_{\text{scramble}, Q}[n] = C_1[n] + C_2[n];$$

and

10 (b) when the spreading data do not vary,

【EQUATION 38】

$$C_{\text{scramble}, I}[n] + j C_{\text{scramble}, Q}[n] = -C_2[n] C_{\text{scramble}, Q}[n-1] H_b[n-1] H_b[n] + j C_2[n] C_{\text{scramble}, I}[n-1] H_a[n-1] H_a[n].$$

4. A transmitting method as defined in claim 2  
 15 or 3, wherein the orthogonal complex-domain  
 spreading is performed with orthogonal Hadamard  
 codes and the scrambling codes for the complex-  
 domain scrambling are produced using orthogonal  
 Hadamard codes.

20 5. A transmitting method as defined in claim 2,  
 wherein the orthogonal complex-domain spreading is  
 performed with orthogonal Walsh codes and the

scrambling codes for the complex-domain scrambling are generated using orthogonal Hadamard codes.

6. A transmitting method as defined in claim 2, wherein the orthogonal complex-domain spreading is performed with orthogonal Gold codes and the scrambling codes for the complex-domain scrambling are generated using orthogonal Hadamard codes.

7. A receiving method in CDMA (Code Division Multiple Access) systems with a transmitting apparatus and receiving apparatus, comprising the steps of:

(a) demodulating the transmitted signal using the same carrier used in the transmitter; (b) de-scrambling the demodulated signal using the synchronized identical PN (Pseudo-Noise) sequences of the transmitter; (c) de-spreading the de-scrambled signal using the synchronized identical orthogonal codes of the transmitter for each channel; and (d) recovering the transmitted data from the de-spread signals.

8. A receiving method as defined in claim 7, wherein the de-scrambling step and the de-spreading

step perform a complex-domain de-scrambling and an orthogonal complex-domain de-spreading.

9. A receiving method as defined in claim 8, wherein the complex-domain de-scrambling codes and  
5 the orthogonal complex-domain de-spreading codes are the same as those used in the complex-domain scrambling and the orthogonal complex-domain spreading of the transmitter.

10. A transmitting apparatus in CDMA (Code  
10 Division Multiple Access) system with the transmitting apparatus and receiving apparatus, comprising:

(a) means for generating a pilot signal and transmitting data signals for several channels with  
15 different information; (b) means for controlling the signal-gains of the channels; (c) means for spreading the gain-controlled signal for each channel; (d) a first complex-domain multiplying means for performing the first orthogonal complex-  
20 domain spreading with the inputs of the transmitting data of the supplementary channels and of the OVSF (Orthogonal Variable Spreading Factor) codes; (e)

means for adding the output of the first complex-domain multiplying means and the spread signal; (f) a spreading modulator, comprising a complex-domain multiplier and a scrambling code generator, for  
5 modulating the added signal; (g) means for amplifying the low-pass filtered signal power; (h) means for modulating the amplified signal to the desired frequency band; and (i) means for adding the modulated signals.

10 11. A receiving apparatus in CDMA (Code Division Multiple Access) systems with a transmitting apparatus and receiving apparatus, comprising:

(a) means for demodulating the transmitted signal  
15 from an antenna using the same carrier used in the transmitter; (b) a spreading de-modulator, comprising a scrambling code generator and complex-domain multiplying means, for de-scrambling the low-pass filtered demodulated signal; (c) means for de-  
20 spreading the de-scrambled signal to get the desired channel by integrating for the symbol period proportional to the data rate of the corresponding



channel; and (d) second complex-domain multiplying means for correcting the phase of the de-spread signal.

12. A receiving apparatus as defined in claim  
5 11, wherein the carrier used in the demodulating means of (a) in claim 11 are the same waves used in the transmitter.



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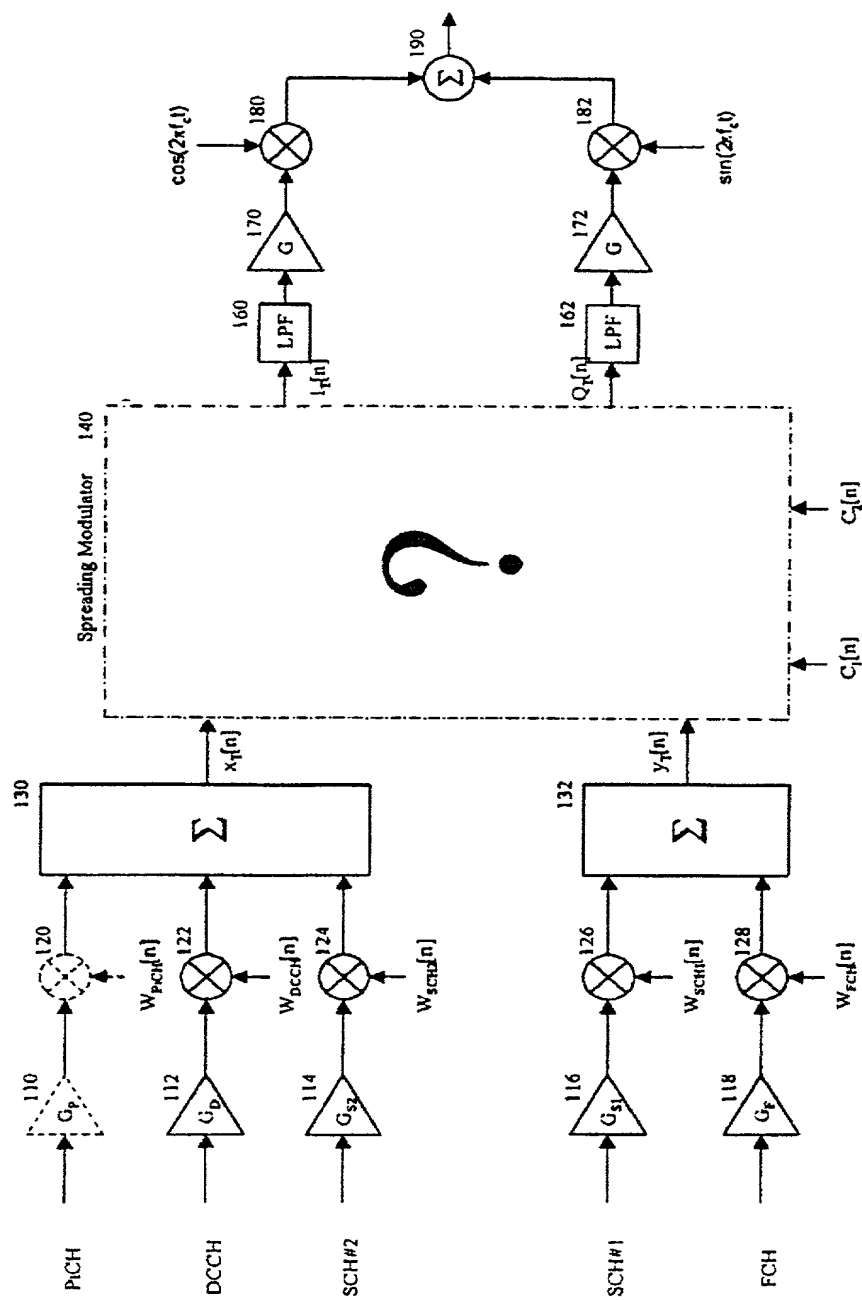


FIG. 1

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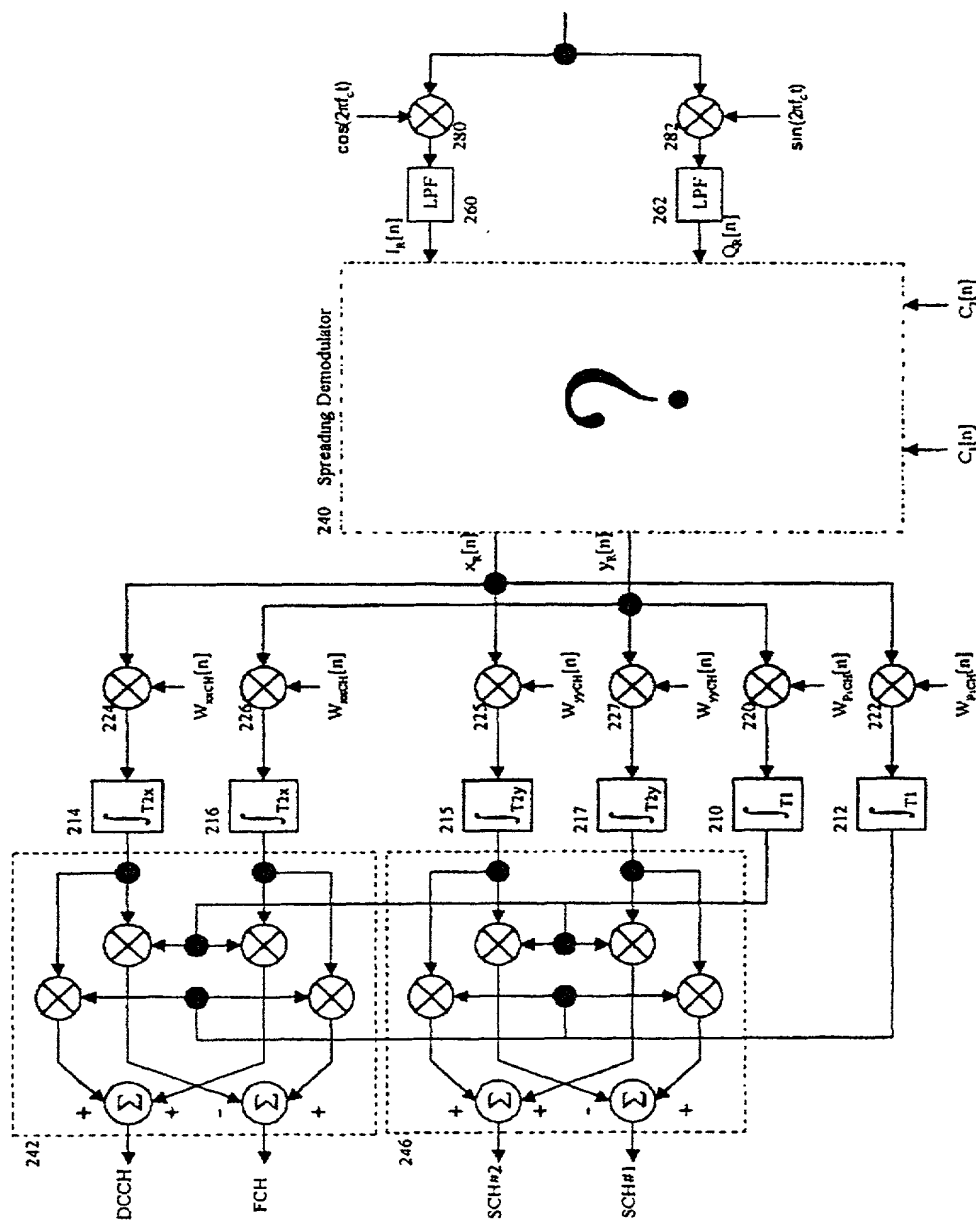


FIG. 2

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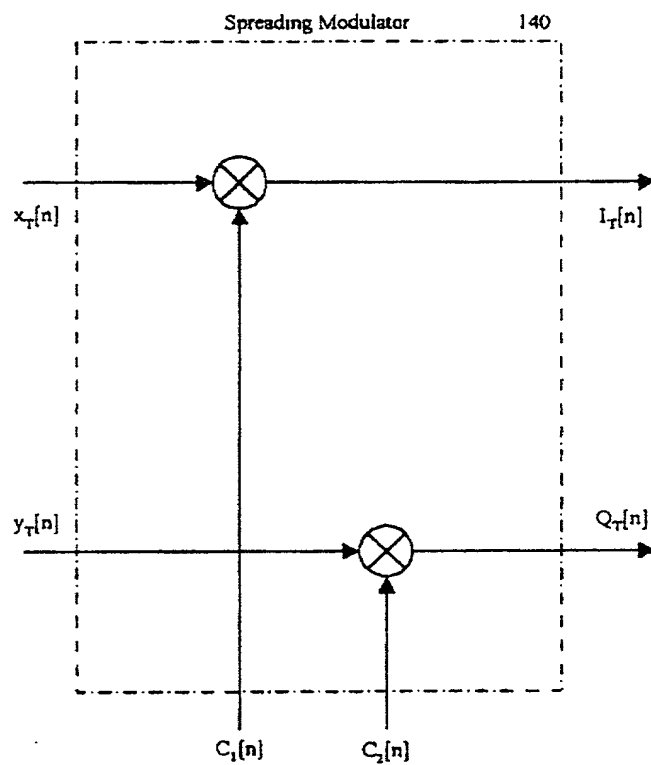


FIG. 3a

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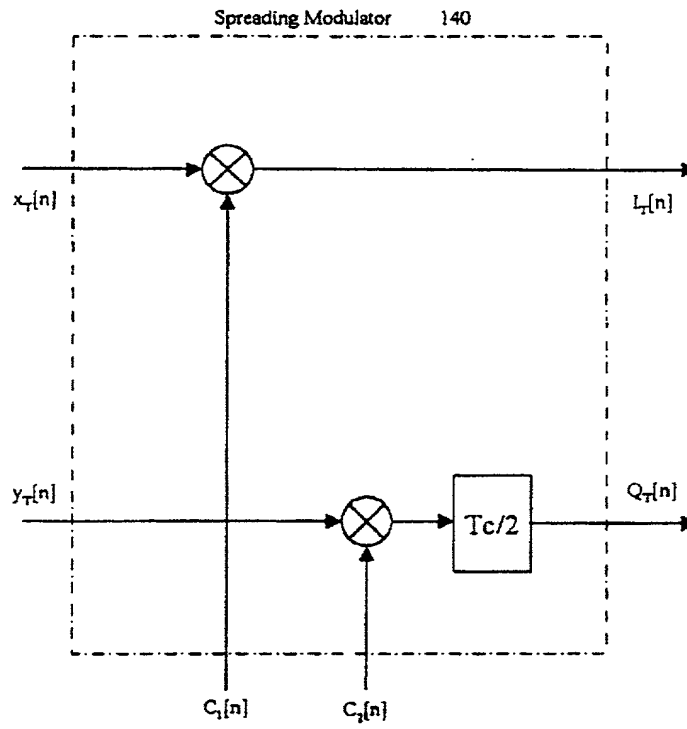


FIG. 3b

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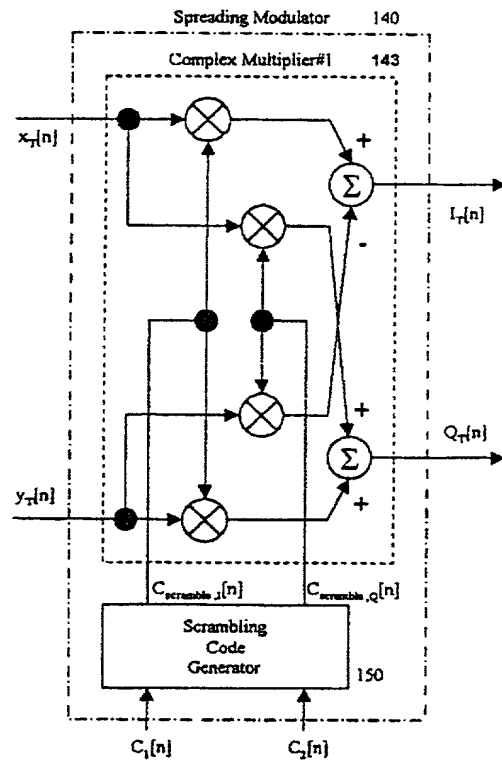


FIG. 3c

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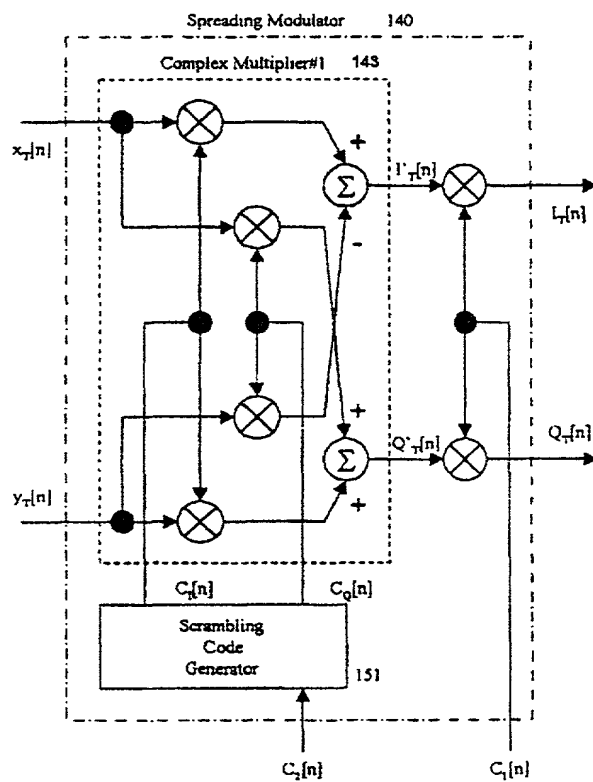


FIG. 3d



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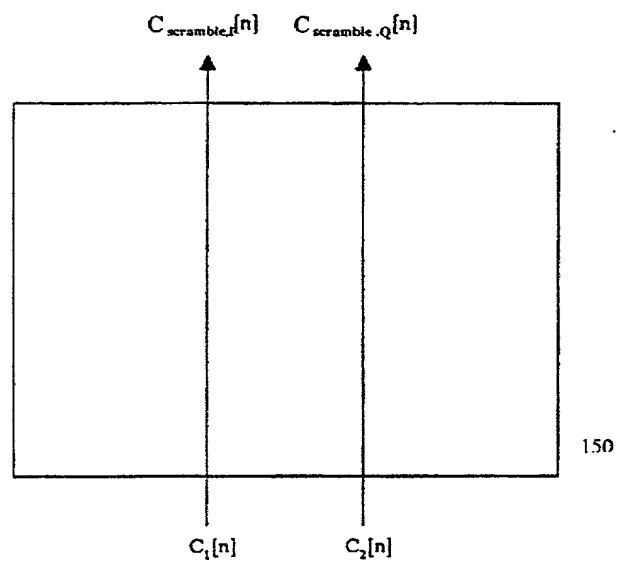


FIG. 4a

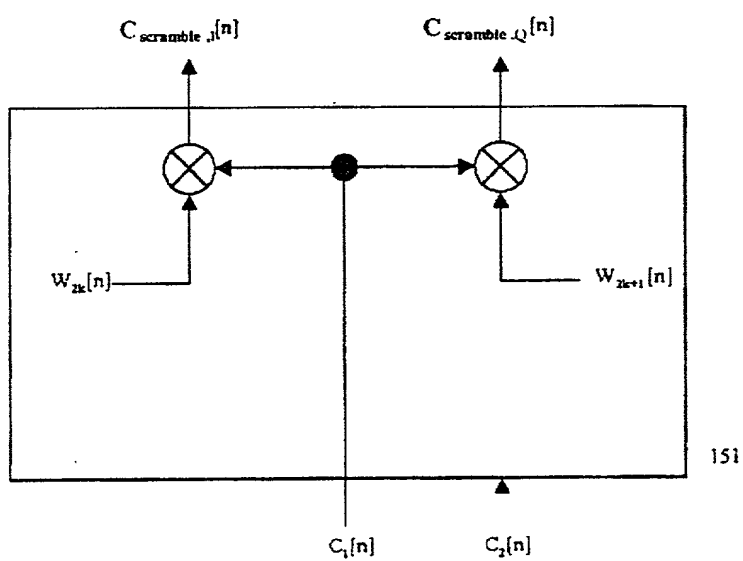


FIG. 4b

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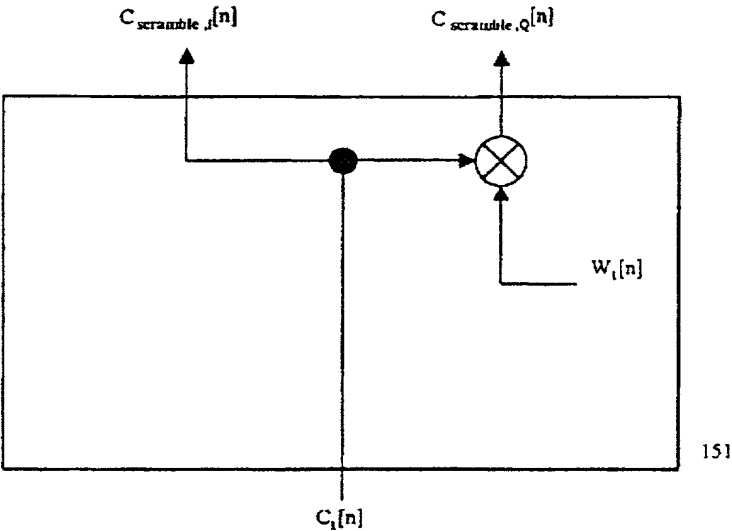


FIG. 4c

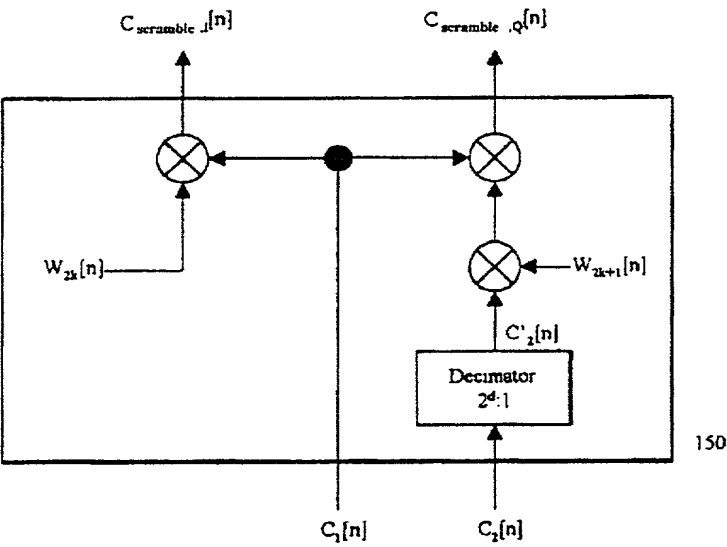


FIG. 4d

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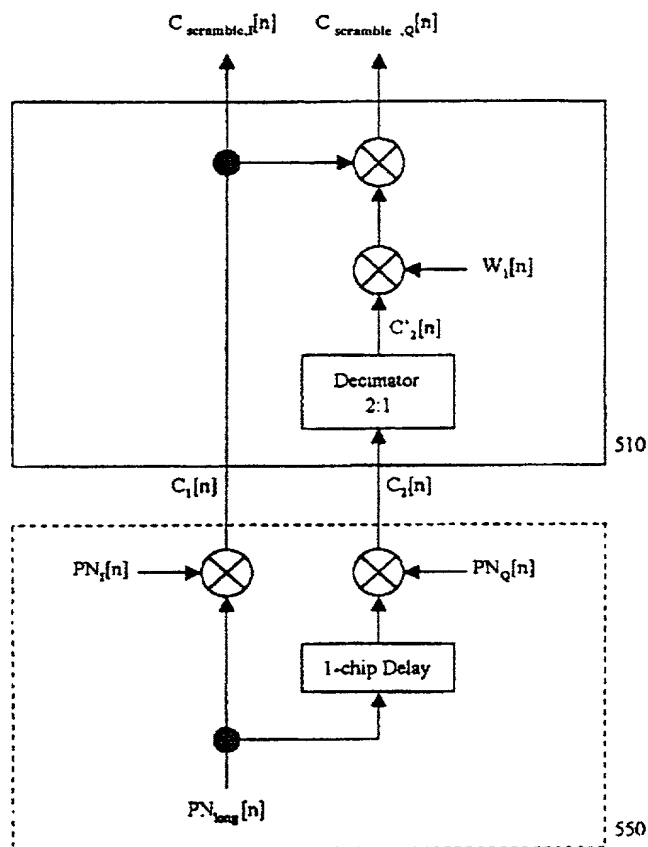


FIG. 5a

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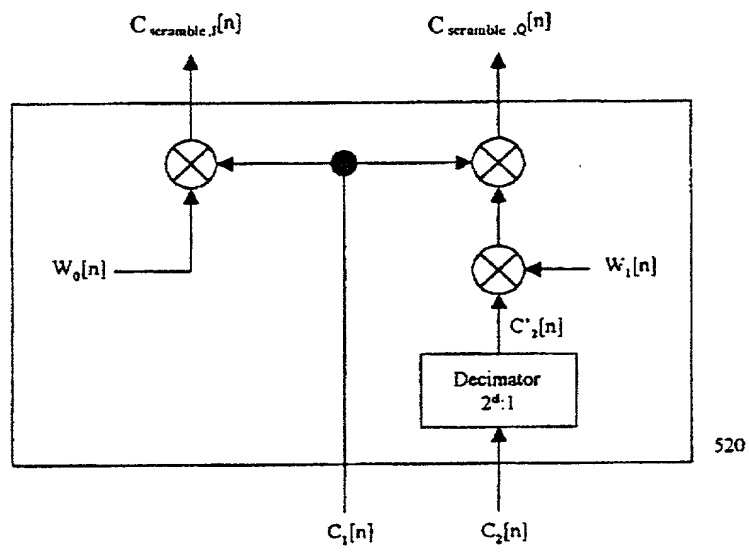


FIG. 5b

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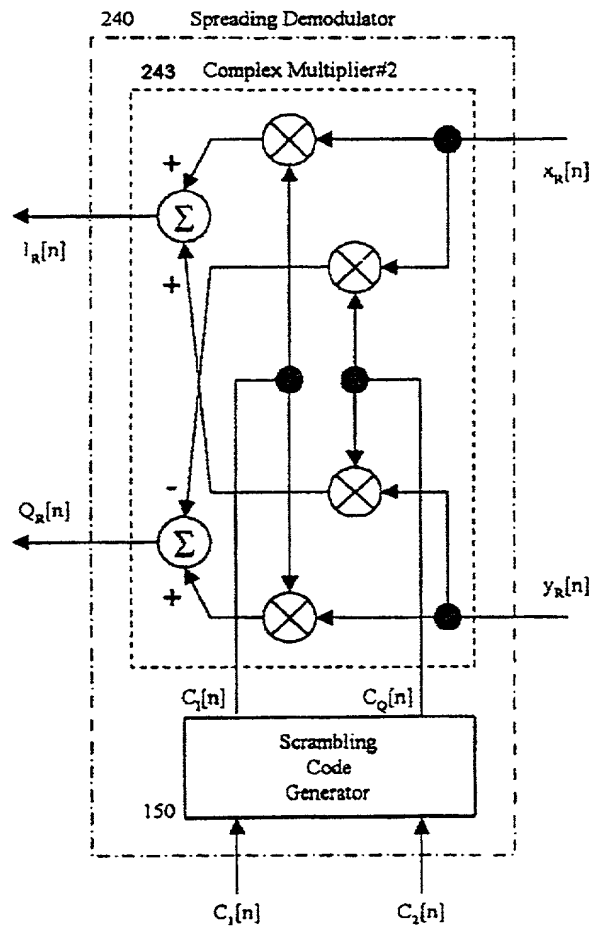


FIG. 6a

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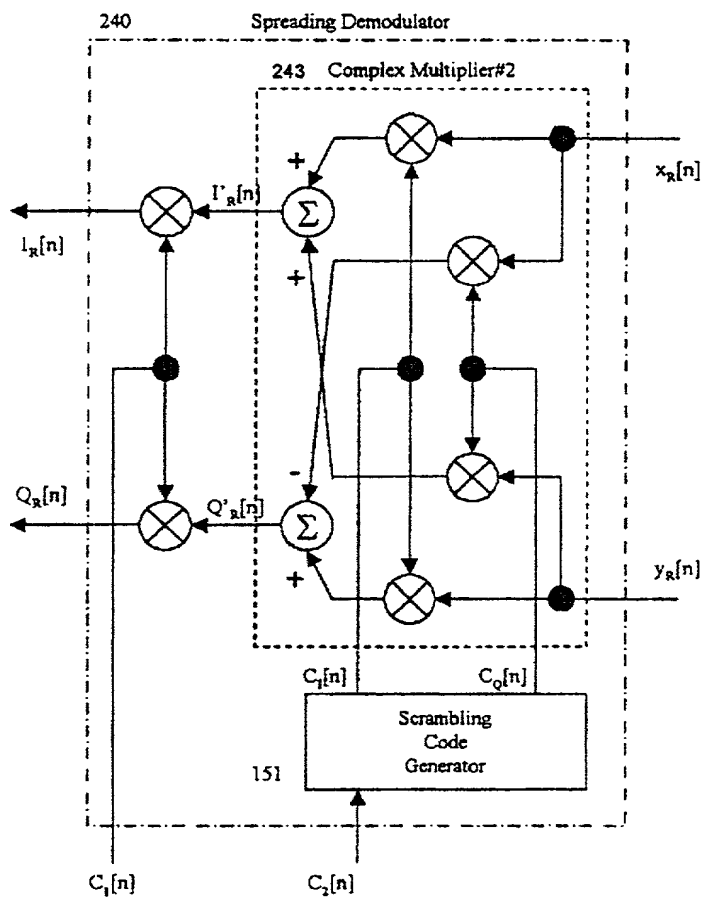


FIG. 6b

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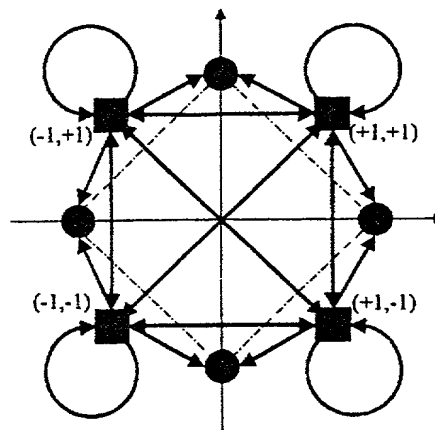


FIG. 7a

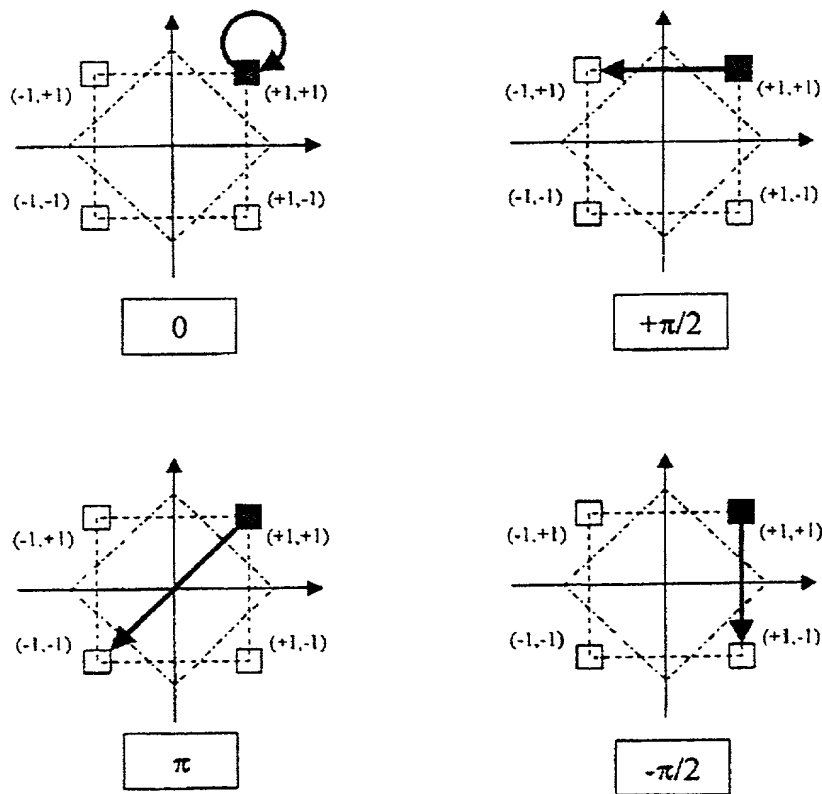


FIG. 7b

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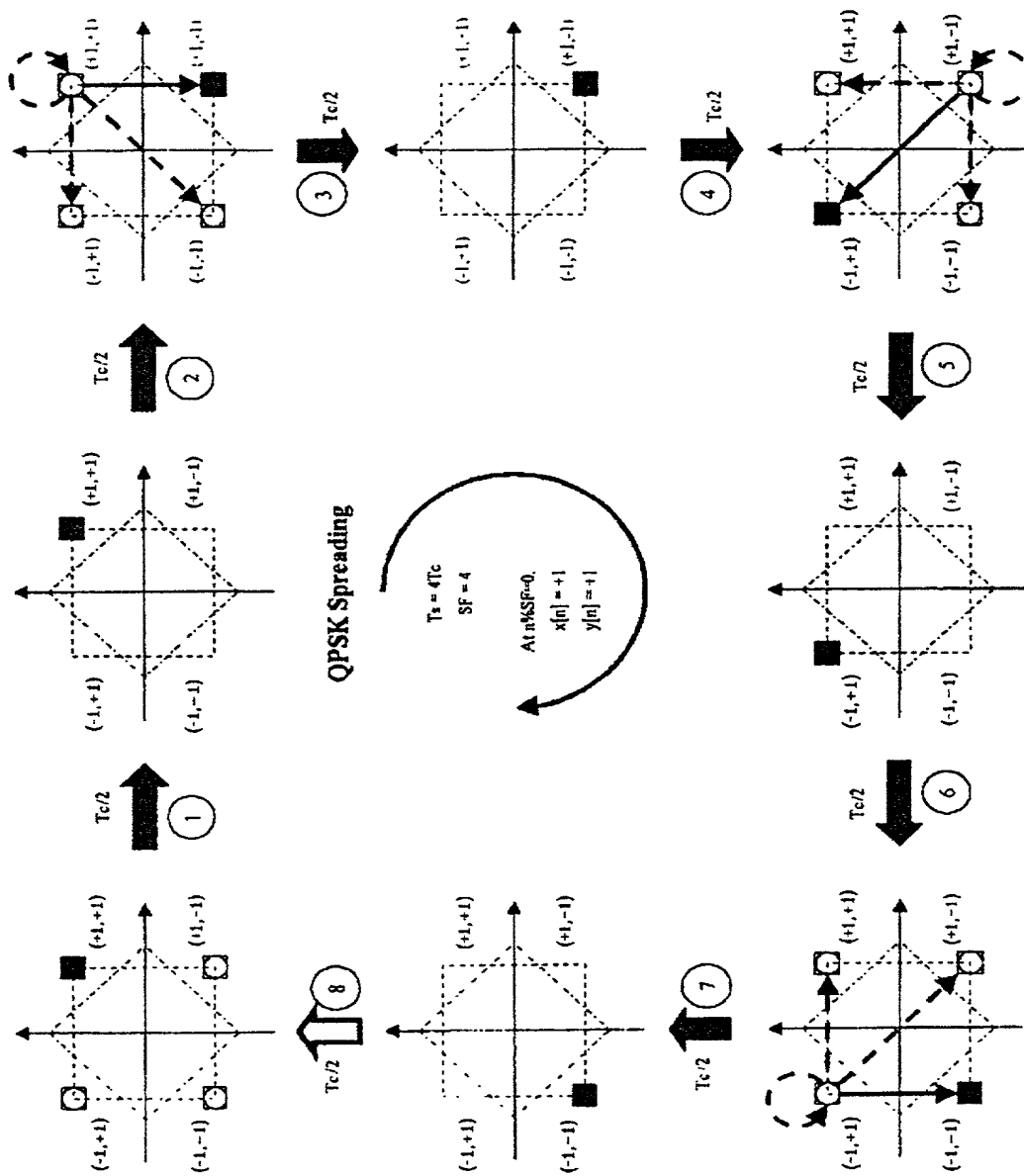


FIG. 8a



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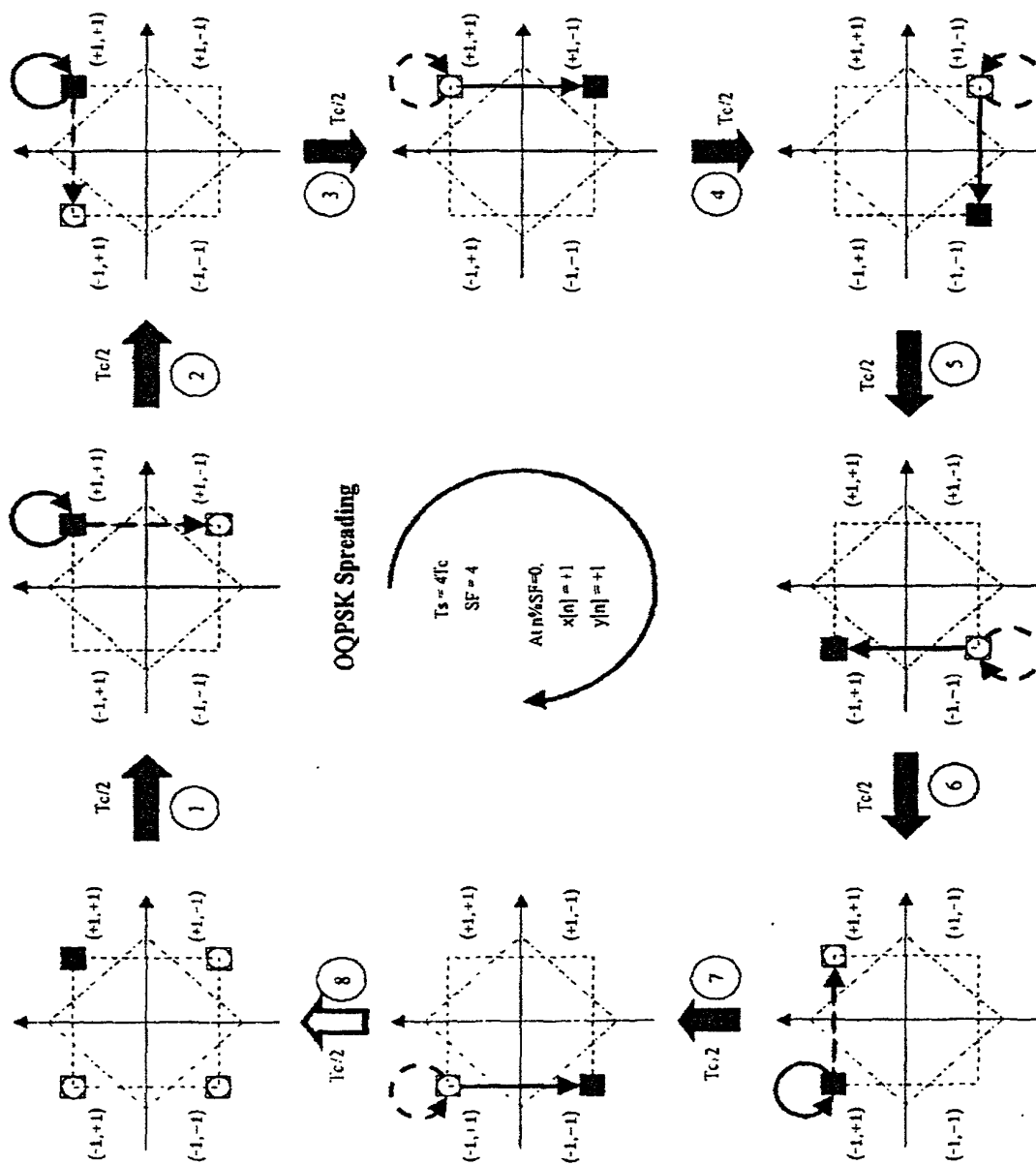


FIG. 8b

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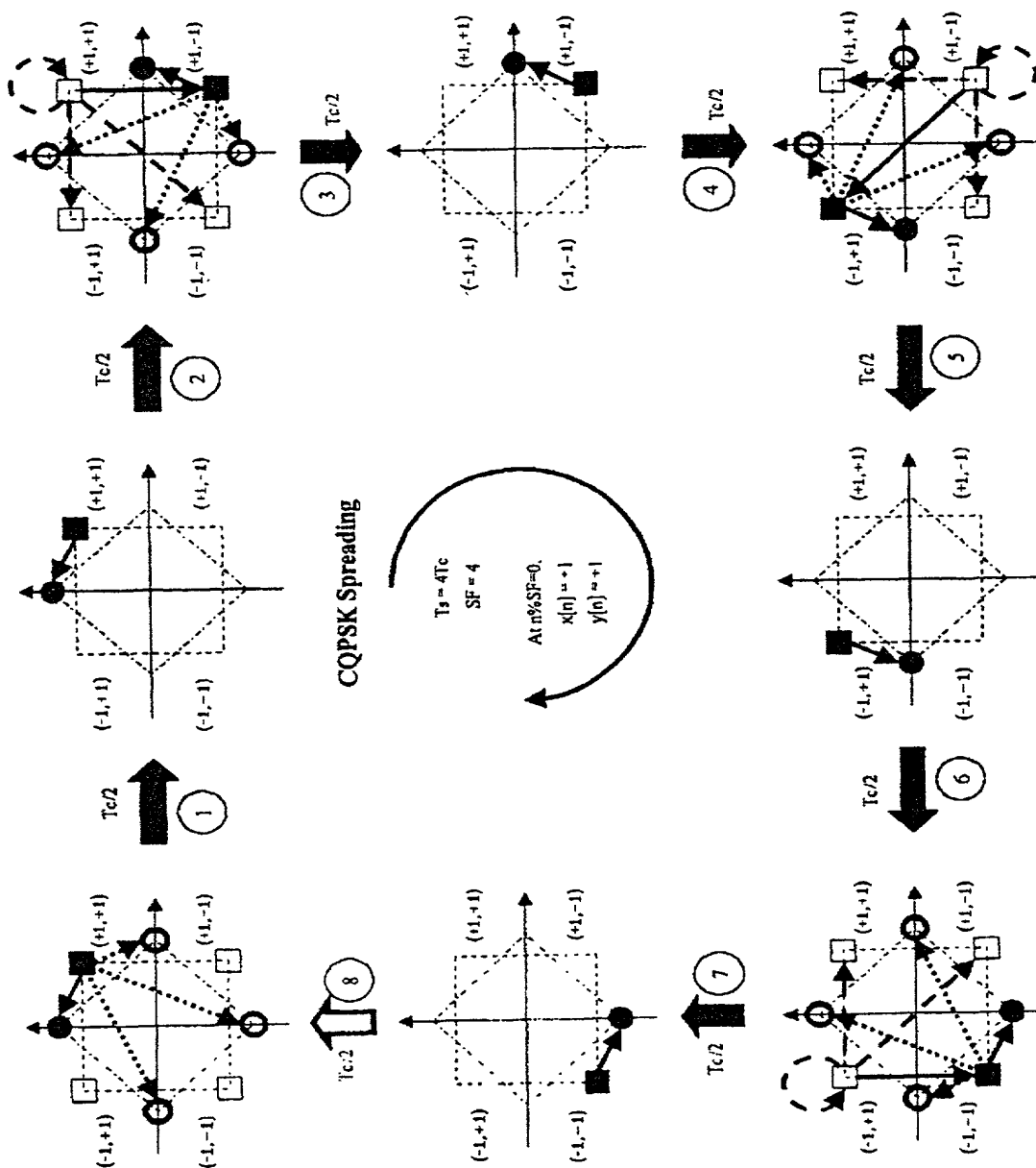


FIG. 8c

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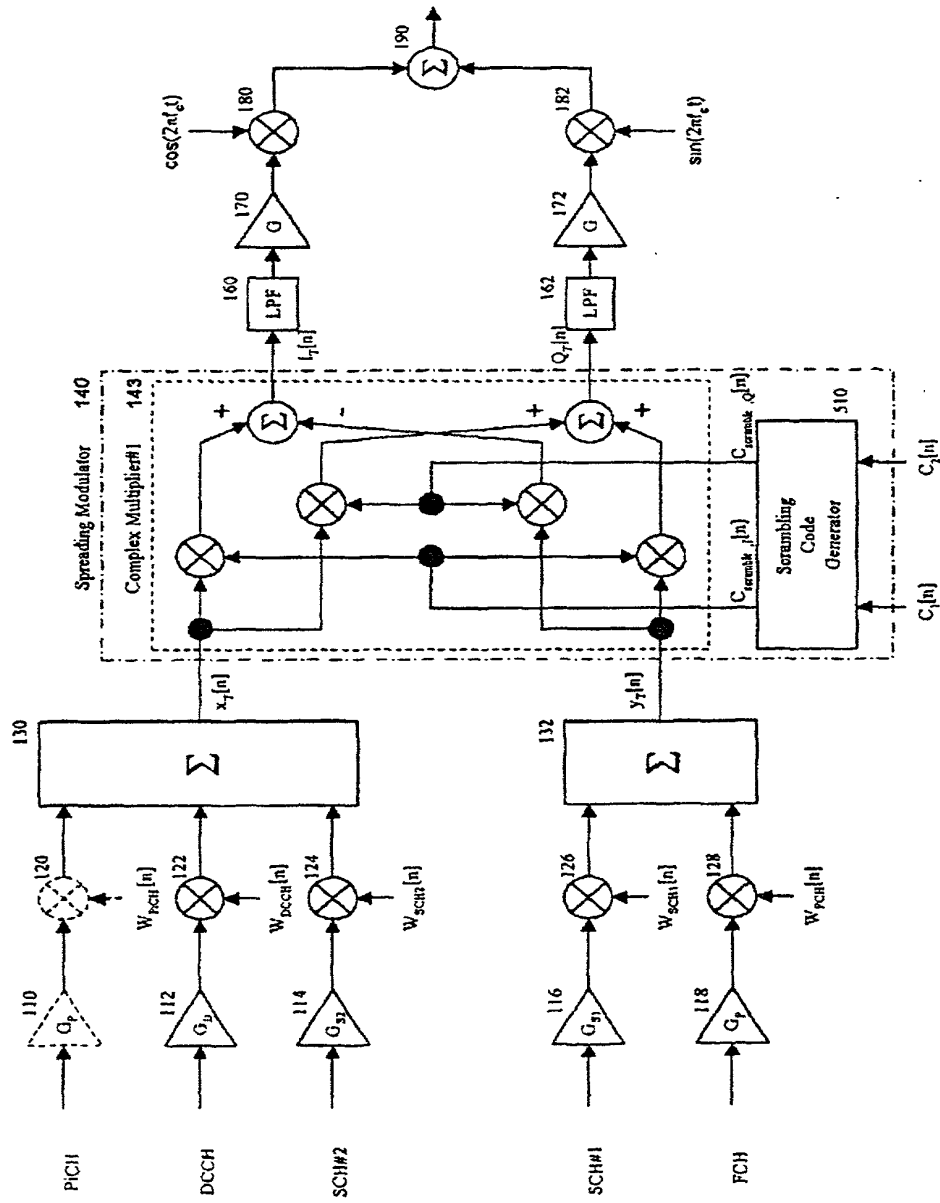


FIG. 9

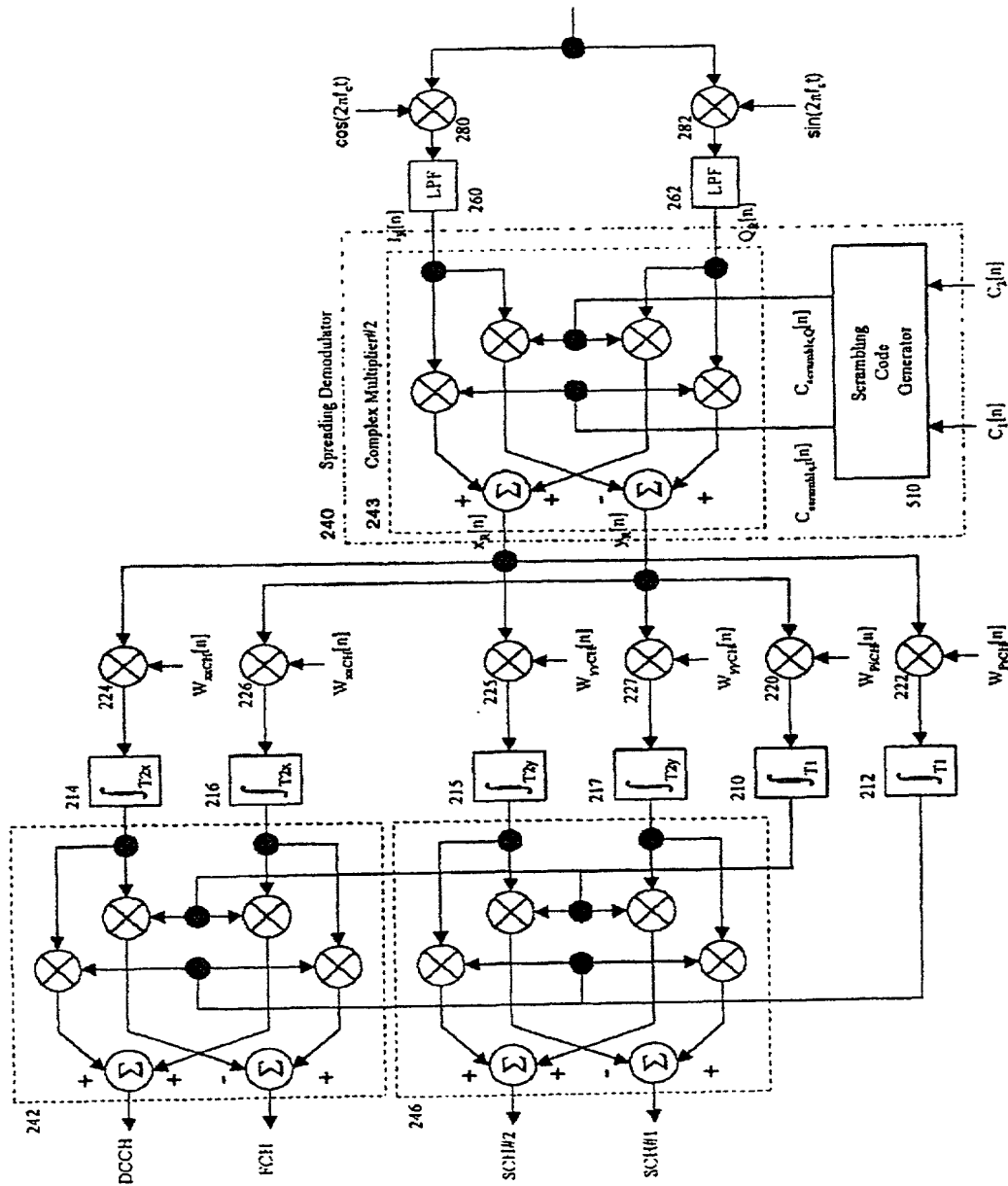


FIG. 10

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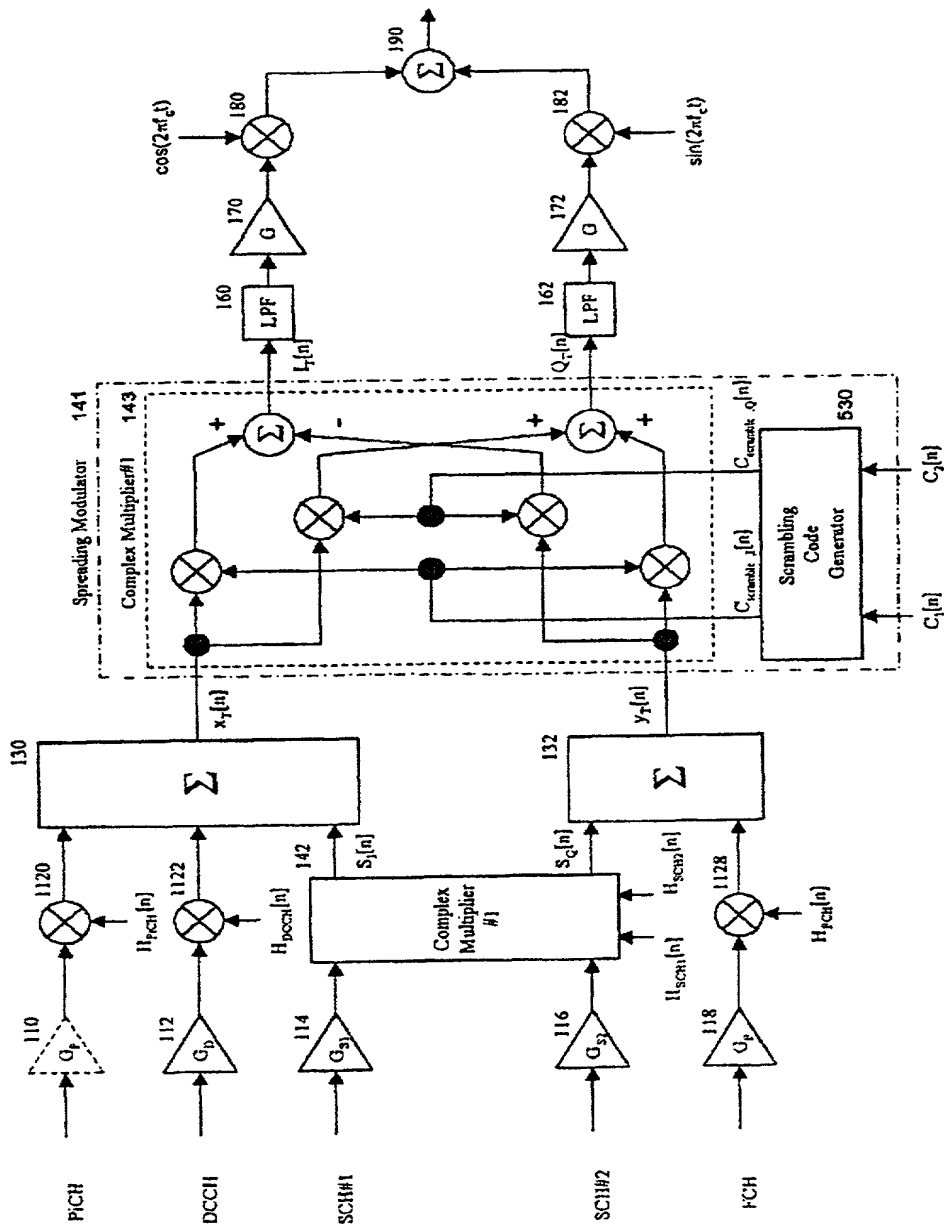


FIG. 11a

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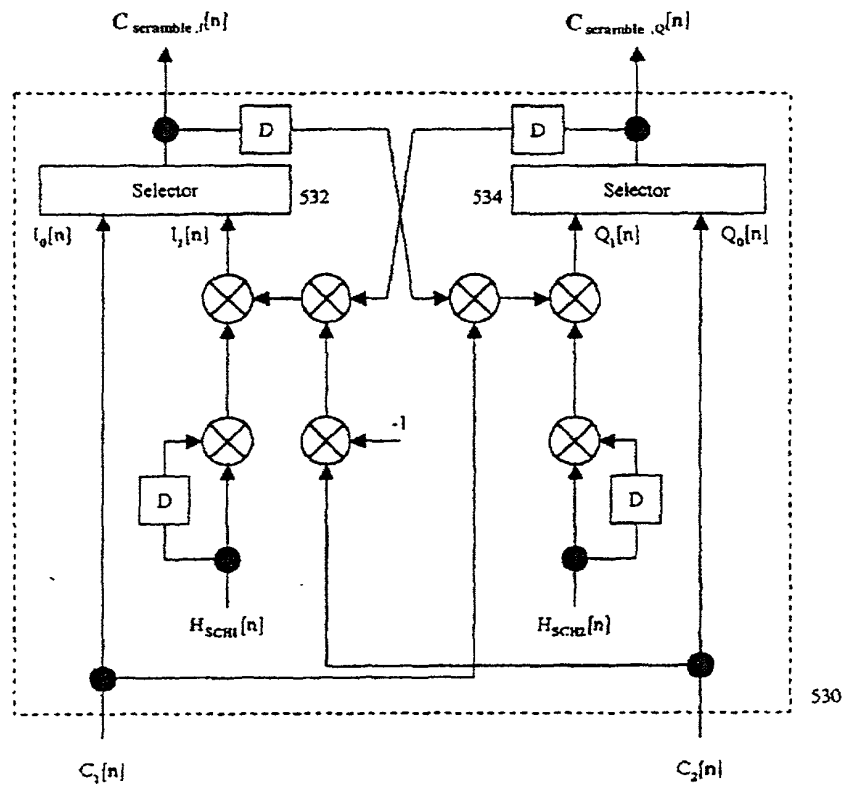


FIG. 11b

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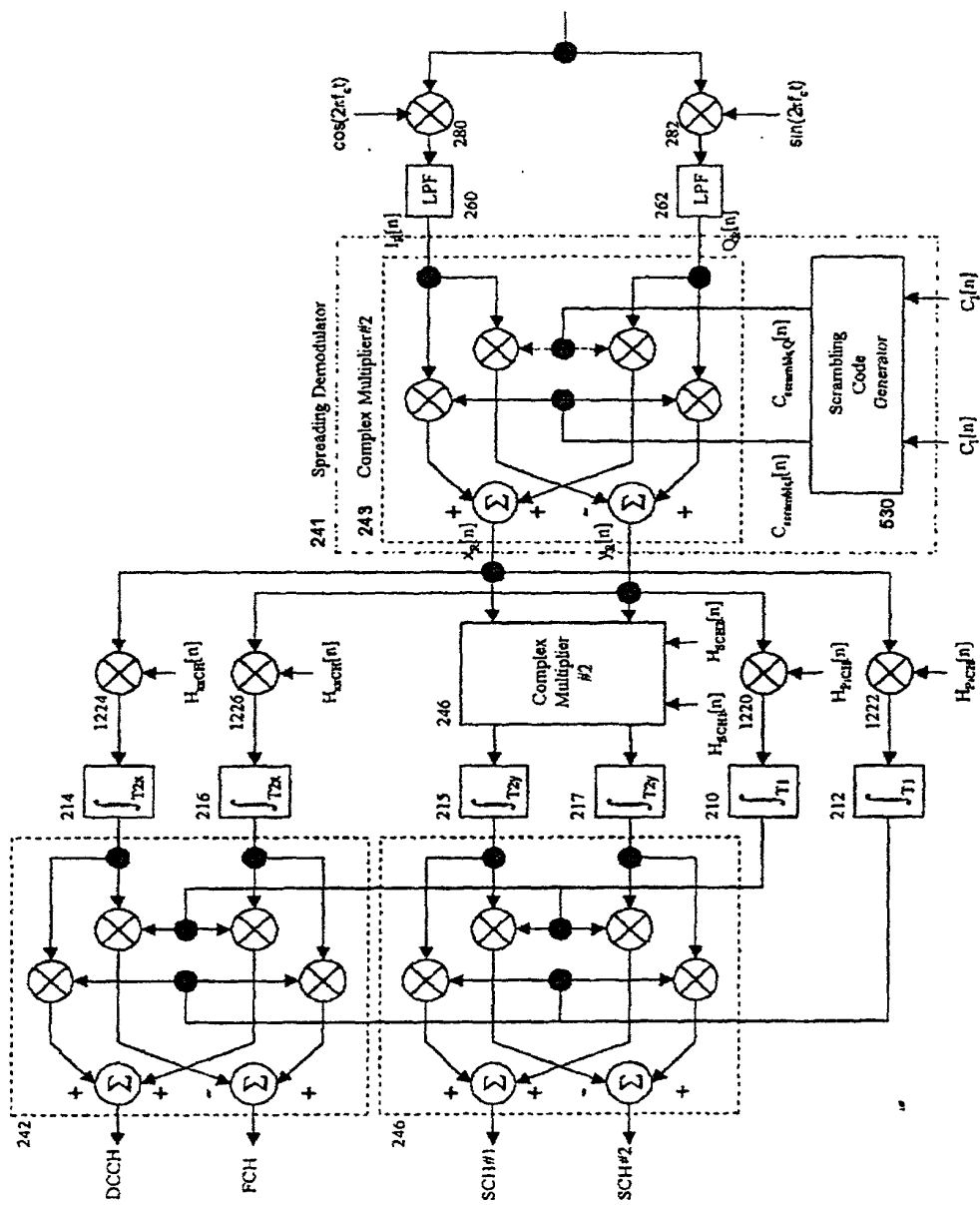


FIG. 12

**DECLARATION FOR PATENT APPLICATION AND APPOINTMENT OF ATTORNEY**

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name; I believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention (Design, if applicable) entitled:

TRANSMISSION AND RECEIVING USING SPREADING MODULATION FOR SPREAD SPECTRUM COMMUNICATIONS AND THEREOF APPARATUS  
the specification of which (check one):

☐ is attached hereto, or ☒ was filed on:

as U.S. Application Number or PCT International Application

Number: PCT/KR00/01385

and (if applicable) was amended on:

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment(s) referred to above. I acknowledge the duty to disclose information which is material to patentability as defined in *Title 37, Code of Federal Regulations, §1.56*. I hereby claim foreign priority benefits under *Title 35, United States Code §119* of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed.

| PRIOR FOREIGN APPLICATION(S) |         |                      | PRIORITY CLAIMED |    |
|------------------------------|---------|----------------------|------------------|----|
| Number                       | Country | Day/Month/Year Filed | Yes              | No |
| 54963                        | KOREA   | 04/12/1999           | X                |    |
|                              |         |                      |                  |    |

☐ Additional Priority Application(s) Listed on Following Page(s)

| I HEREBY CLAIM THE BENEFIT UNDER TITLE 35 U.S. CODE §119(E) OF ANY U.S. PROVISIONAL APPLICATIONS LISTED BELOW. |                      |
|--|----------------------|
| Application Number   | Day/Month/Year Filed |
|  |                      |
|  |                      |

☐ Additional Provisional Application(s) Listed on Following Page(s)

I hereby claim the benefit under *Title 35, United States Code, §120* of any United States application(s) or PCT international application(s) designating The United States of America listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of *Title 35, United States Code, §112*, I acknowledge the duty to disclose information which is material to patentability as defined in *Title 37, Code of Federal Regulations, §1.56* which became available between the filing date of the prior application(s) and the national or PCT international filing date of this application:

| Application Number | Filing Date | Status - Patented, Pending or Abandoned |
|--------------------|-------------|---|
|                    |             |   |
|                    |             |   |

☐ Additional US/PCT Priority Application(s) listed on Following Page(s)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under *section 1001 of title 18 of the United States Code* and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: I (We) hereby appoint as my (our) attorneys, with full powers of substitution and revocation, to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: J. Ernest Kenney, Reg. No. 19,179; Eugene Mar, Reg. No. 25,893; Richard E. Fichter, Reg. No. 26,382; Thomas J. Moore, Reg. No. 28,974; Joseph DeBenedictis, Reg. No. 28,502; Benjamin E. Urcia, Reg. No. 33,805; and

I (we) authorize my(our) attorneys to accept and follow instructions from \_\_\_\_\_ regarding any matter related to the preparation, examination, grant and maintenance of this application, any continuation, continuation-in-part or divisional based thereon, and any patent resulting therefrom, until I (we) or my(our) assigns withdraw this authorization in writing.

Send correspondence to:

**BACON & THOMAS, PLLC**  
625 Slaters Lane - 4th Floor  
Alexandria, VA 22314-1176

Telephone Calls to: (703) 683-0500

|   |   |
|---|---|
| FULL NAME OF FIRST OR SOLE INVENTOR<br><u>KIM, JONG MYEONG</u>  | CITIZENSHIP<br>KOREA  |
| RESIDENCE ADDRESS<br>108-203, JUGONG APT., OKPO-2DONG, KEQJE, KYUNG NAM, 656-132, REPUBLIC OF KOREA<br><u>KRX</u> | POST OFFICE ADDRESS IS THE SAME AS RESIDENCE ADDRESS UNLESS OTHERWISE SHOWN BELOW |
| DATE<br>JULY 24, 2001   | SIGNATURE<br><u>Kim</u>   |

☐ See following page(s) for additional joint inventors.



## CONTINUATION OF DECLARATION FOR PATENT APPLICATION AND APPOINTMENT OF ATTORNEY

Page \_\_\_\_

| PRIOR FOREIGN APPLICATION(S) (35 USC §119) |         |                      | PRIORITY CLAIMED |    |
|--|---------|----------------------|------------------|----|
| Number                                     | Country | Day/Month/Year Filed | Yes              | No |
|  |         |                      |                  |    |
|  |         |                      |                  |    |

| PRIOR PROVISIONAL APPLICATIONS 35 U.S. CODE §119(E) |                      |
|---|----------------------|
| Application Number                                  | Day/Month/Year Filed |
|   |                      |
|   |                      |

| PRIOR U.S. OR PCT INTERNATIONAL APPLICATIONS (35 U.S. CODE §120) |             |   |
|--|-------------|---|
| Application Number   | Filing Date | Status - Patented, Pending or Abandoned |
|  |             |   |
|  |             |   |

|   |   |
|---|---|
| FULL NAME OF JOINT INVENTOR<br><u>2-00</u> PARK, SU WON   | CITIZENSHIP<br>KOREA  |
| RESIDENCE ADDRESS<br>DEPARTMENT OF ELECTRICAL ENGINEERING, KAIST,<br>KUSONG-DONG, YUSONG-KU, TAEJON, 305-701,<br>REPUBLIC OF KOREA <u>KRX</u> | POST OFFICE ADDRESS IS THE SAME AS RESIDENCE ADDRESS UNLESS OTHERWISE SHOWN BELOW<br><u>102 15 21</u> |
| DATE<br>JULY 24, 2001   | SIGNATURE   |

|  |  |
|--|--|
| FULL NAME OF JOINT INVENTOR<br><u>3-00</u> SUNG, DAN KEUN  | CITIZENSHIP<br>KOREA   |
| RESIDENCE ADDRESS<br>103, 1503, HANWOOL APT., SHIN SUNG-DONG,<br>YUSONG-KU, TAEJON, 305-345,<br>REPUBLIC OF KOREA <u>KRX</u> | POST OFFICE ADDRESS IS THE SAME AS RESIDENCE ADDRESS UNLESS OTHERWISE SHOWN BELOW<br><u>KD</u> |
| DATE<br>JULY 24, 2001  | SIGNATURE  |

|                             |   |
|-----------------------------|---|
| FULL NAME OF JOINT INVENTOR | CITIZENSHIP   |
| RESIDENCE ADDRESS           | POST OFFICE ADDRESS IS THE SAME AS RESIDENCE ADDRESS UNLESS OTHERWISE SHOWN BELOW |
| DATE                        | SIGNATURE   |

|                             |   |
|-----------------------------|---|
| FULL NAME OF JOINT INVENTOR | CITIZENSHIP   |
| RESIDENCE ADDRESS           | POST OFFICE ADDRESS IS THE SAME AS RESIDENCE ADDRESS UNLESS OTHERWISE SHOWN BELOW |
| DATE                        | SIGNATURE   |

☐ See following pages for additional joint inventors/priority applications.